ANALYSIS AND DECISION

A FRAMEWORK FOR ESTIMATING CAPITAL AND OPERATING COSTS IN THE URBAN TRANSPORTATION PLANNING PROCESS

by

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Submitted to the Department of Urban Studies and Planning in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Urban and Regional Planning

at the

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Signature of Author

Certified by

Ralph Gakenheimer
Professor of Urban Studies and Planning and Civil Engineering, Thesis Supervisor

Accepted by

Langley Carleton Keyes
Director of the PhD Program
A mis padres
The easiest thing of all is to deceive oneself for what a man wishes he generally believes to be true.

Demosthenes
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ABSTRACT

The underestimation of capital and operating costs in the process of analyzing transit alternatives has been highlighted as one of the critical points that deserve special attention to strengthen the transportation planning process. A reliable estimate of the costs of constructing, operating and maintaining alternative transit projects is crucial to the evaluation of the cost-effectiveness and financial implications of those alternatives and, hence, of the merits of each alternative vis-a-vis the others.

This thesis investigates the underestimation process from both the technical and the decision-making perspectives and concludes with an assessment of the role of technical analysis in informing the decision-making function. It develops a framework for the estimation of capital and operating costs in transit-project planning encompassing the components of (a) the technical dimension, with the definition of its inputs, models, and outputs; (b) the decision-making dimension, with the definition of the actors, organizations, their interactions, and the external political-institutional environment; and (c) the relationship between those two dimensions. The research methodology consists of a case study approach that bases its analytical framework on a social-argumentative paradigm within which the planning process is seen as the interaction between the technical analysis (information), the constraints and characteristics of the decision-making function, and the actors' personal values and beliefs. That framework also rests on a normative basis of unbiased information and democratic values. This paradigm allows one to identify and understand the factors that shape decisions and influence the technical process.

Three major set of issues are recognized as common themes of reference in the case studies. Within the technical set: the sources of rises in capital and operating costs; the special features of fixed-guideway systems (mainly, their permanence) and the implications of these features on the development of the project and the support for it by the affected constituencies; and the requirements of the technical process. Within the decision-related set: the explicit or implicit motivations for proposing the system; the local versus central government contentions about the viability of the transportation projects and the reflection of these contentions on cost estimates; and the constraints and requirements on the decision-making process. Finally, as to the relationship between analysis and decision: the interaction between analysts and decision makers, and
between funding institutions and decision makers; the force of optimistic expectations on the analysis process; and the different interpretations of the intent of alternatives analysis requirements and the perception of decision makers about the role of the technical process. The discussion of these issues illustrates the difficulties of achieving an impartial and comprehensive technical planning process, and shows how the process unfolds as a struggle over ideas with a strategic purpose generated by the political environment surrounding that process.

The review of the technical process illustrates how the cost-estimating approach must be tailored to the decision environment, how cost classifications can help understand the implications of changes in other uncertain estimates, and how the management of cost information can help organize and structure the cost estimating process. It also reveals that certain difficulties of the technical process leave ample room for deviations from an ideal impartiality, although specific actions could be taken to get closer to that ideal. Nevertheless, as the design of the technical process affects itself, the success or failure of the cost estimating process depends on how useful it is to achieve a particular role in the decision-making process, rather than simply its accuracy or the sophistication of its technical development. The importance of the decision criteria used to rate the alternatives, the need to acknowledge the multiple perspectives involved in the process, and the difficulties that surround decision-makers' responsibilities are some of the issues that frame the prevalent decision-making process.

The discussion of the technical and decision-making processes and of the relationship between them lead to suggested improvements in the estimating function that may not necessarily transcend into more accurate cost estimates but will induce a decision-making process that would tend to reflect the limitations and difficulties of the transit-project planning process. The ever-changing nature of the planning environment suggests the broadening of the classic "goal-definition-analysis-evaluation-selection" model of planning to take into account the negotiated, politically-influenced character of the decision-making process.

The discussion of the proposed framework (uncertainty, scope and time scales, information management, decision criteria, and decision payoffs) suggests measures that can enhance the effectiveness of the technical as well as the decision-making process. Sensitivity analyses, improved information systems, negotiated criteria, and "accuracy" incentives are some of the measures identified to make the process closer to the normative basis. Overall, these measures suggest an approach that attempts to tackle the level of uncertainty of some elements (mainly the elements that compose the technical data and methods) and, at the same time, opens the discussion over the assumptions and definitions of other elements of the transit planning process (mainly the goals to be achieved with the transit project and the criteria to be used to judge the merits of each alternative).

Thesis Supervisor: Ralph Gakenheimer
Title: Professor of Urban Studies and Planning and Civil Engineering
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An endeavor like a doctoral dissertation cannot be undertaken without the support of many people, and more if the dissertation is based on a case study approach requiring extensive interviews and the gathering of a substantial amount of dispersed information. Because of this, it is not possible to list here the many people that one way or another contributed to the completion of this study. I would like to mention, however, those that for their position or because of the circumstances made a larger contribution towards the completion of this thesis. This is not to say that the many others deserve less recognition.

In relation to the case studies, I must thank, in Santa Clara County, David Minister, in Boston, Bob Lepore, in Buffalo, Gordon Thompson, and in Washington, Don Emerson, who all provided me with inestimable information and excellent and clear overviews of the different case studies they were involved with. For the cases abroad, in both of which I personally participated, I must thank Javier Bustinduy in Spain for the several occasions we spend together discussing the transportation system of Madrid, and Hugo Eduardo Beteta who, in the difficult project we undertook in La Paz, was an enthusiastic and tenacious companion. To all of them my gratitude for their patience, for putting up with my sometimes too harsh arguments, and for making constructive comments to them.

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But all the work would have had less meaning if it had not been to the many friends with whom I was related during the years I spent at MIT and who one way or another made the whole process of the Ph.D. program more gratifying. Among them, I extend my appreciation to Hugo Eduardo Beteta, Francisco Martín Carrasco, Emily Susan Jonas (who patiently edited the final draft of this thesis), and Elena Diez Pinto.

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Finally, I must endlessly thank my parents and my brothers and sisters, Mercedes, Belén, Pablo, Begoña, Rodrigo, and Gerardo, who, far from here but very close to my heart, have been, are, and will always be, the major reason for the efforts that I have undertaken outside my home country. To them, my deepest gratitude for their tireless understanding, support, and patience.
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5.3. Comparative Indicators from Several Systems in the U.S. (Fiscal year ending between 01/01/83 and 12/31/83) ................................................ 227
1. INTRODUCTION

1.1. Purpose of the Thesis

The ultimate purpose of this thesis is to examine how decision makers use technical analysis in the urban transportation planning process. To accomplish that purpose, the thesis focuses on the process of estimating capital and operating costs in the phase of analyzing transit-project alternatives and develops a framework for that estimating process. The framework attempts to show the interaction between the technical aspects involved in the process of establishing capital and operating costs of transit alternatives and the institutional, political, and decision-making dimensions of that process.

The purpose of estimating is to predict, as accurately as possible, a future condition -- in this case, a future cost. Estimating is one of the most crucial, controversial, and relevant activities in any planning process for, based on the estimation of the values of a set of variables (e.g., demand, costs, population), plans are developed and decisions are made. One of the reasons for focusing on the process of cost estimation is that, unlike other aspects of planning, cost estimates have an exact basis for ultimate judgement. We can, eventually, determine how accurate the estimates were (accounting, if necessary, for any changes in project design and/or scope). Unfortunately, however, we do not usually learn much about accuracy until the decision has already been made, the project has been implemented, and it is too late to undo what has been done.

A set of studies related to cost estimating focuses on the technical aspects involved in developing analytic methods for calculating capital and
operating costs. In these studies the estimating process consists of a clear and precise sequence of steps: definition of alternatives, identification of components, gathering of unit-cost data, selection of estimating methods, generation of cost estimates for each alternative, consideration of uncertainties, review, and documentation. However, frequently there are deviations from that process: some steps are missing, the order of the steps are changed, and/or the allocation of time and resources is concentrated on a few steps to the detriment of other steps. These deviations may increase the possibilities of generating, accidentally or intentionally, biased estimates, which in turn may lead to "inadequate" decisions ("inadequate" in the sense that the selection is done on the basis of inaccurate information).

Another trend in the literature emphasizes the institutional aspects of the implementation of transportation plans and how the technical process should be modified to become more effective. This literature indicates that decision makers need good qualitative data, in addition to the quantitative data, as well as techniques for identifying problems and constraints in order to improve the effectiveness of the planning process so that plans do not get stalled once they are approved.

Clark [1985]; Bay [1984]; Stewart [1982]; Calder [1976].


Meyer and Miller [1984] state that "[t]he product of planning can be any form of communication with decision makers that provides useful information in identifying alternative actions and selecting among them" (p. 1). They further state that the types of data should be broadened to include information "relating to the policy, organizational, and fiscal environment of transportation decision making" (p. 10).
Since the period when planning was thought to be a purely technical process, there has been a growing awareness and analysis in the literature of the dynamics of the political and institutional setting within which the transportation planning process is conducted. That setting influences the planning process and generates a picture that differs from the unbiased and value-neutral intention of the technical process. Many factors, such as the interaction among the different levels of government, the pressure exerted by interest groups, and the way information is collected and transmitted to decision makers, affect the final outcome and the selection of the "optimal" alternative ("optimal" in the sense that it is the solution the concerned decision makers think is the best, on the basis of the information generated by the planning studies).

Along these lines, this thesis investigates how data and techniques can be influenced by institutional and political factors, and how these factors may override the technical process. By bringing together the different perspectives -- the technical, the institutional, and the political --, the thesis provides a description and explanation of the dynamics involved in the cost estimating process, in particular, and the process of analyzing transit alternatives, in general.

One can view this thesis from at least two vantage points. From one vantage point, it describes a broader framework to look at the cost estimating process and the processes of analyzing transit alternatives and planning for transportation systems. After the discussion of the motivation for the thesis and the research methodology in this introductory

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4 Altshuler [1979], Witt [1982], Johnston, et.al. [1988], Moore [1988], Catanese [1984], Deiter [1985], Dorschner [1985].
chapter, chapter 2 discusses the history of transportation planning and develops the general theoretical framework. Chapter 2 presents the case studies and the empirical findings as they relate to the issues presented in this thesis. Chapters 4 and 5 each describe one component of that model. Chapter 4 describes the technical, analytic process; it encompasses its elements and techniques. Chapter 5 discusses the theoretical and empirical underpinnings of modern decision-making theory, and puts this theory within the context of the alternatives analysis and cost estimation process. In chapter 6, the two components are brought together to define a framework for estimating capital and operating costs and draws the practical recommendations that generate from that framework. Finally, chapter 7 presents the conclusions to the thesis and highlights those areas that require further research.

From the other vantage point, the thesis is a comprehensive essay on theory and practice of estimation in transportation planning. The second, third, fourth, and fifth chapters encompass three major sections: a presentation of empirical findings, a survey of past research, and a critical look at this research. As a whole, the suggested framework provides opportunities for strengthening and improving the estimation process of any planning activity.

1.2. Motivation for the Research

The motivation for this research comes from the concern raised by the discrepancies usually present between the planning estimates of capital and operating costs of transit alternatives and the costs obtained in the final design of the selected alternative. However, the motivation is broader
than better understanding the chronic underestimation in that the conclusions can be applied to other areas in the planning profession that rely on estimates of future values. The development of a framework for the cost estimating process -- that is, the systematic structure of ideas and elements related to the estimation of costs -- will highlight the interplay between the different actors and identify those elements that affect the "assumed" neutrality of the process and along which a "better" estimation process could be developed ("better" in the sense that a broader set of elements, in addition to the formal technical elements, is considered, that the tendency to bias the results is reduced, and consequently that the decision is made on the basis of more accurate information).

It is important to improve the estimation process for a variety of reasons. The most salient reason stems from the consequences of a failure in estimating costs that are close to final actual costs. This failure may cause all or some of the following problems:

a) Selection of a non-cost-effective alternative, at least from society’s perspective (that is, one where the selected alternative yields costs that are larger than the benefits, as these costs and benefits relate to the society as a whole);

b) If operating costs exceed revenues by more than expected, proceeds needed to assure long-term financing will not be available (e.g., to pay back bond indebtedness, cover debt service, etc.);

c) If capital costs turn out to be much higher, the confidence that project participants place in the planning process and in analysts’
attempt in predicting inflation and escalation would decrease, and would likely result in delays, anger, and distrust in the construction of the project;

d) If either capital or operating costs turn out to be higher than forecast, they may generate problems in raising the additional needed revenues and may create strains with the institutions providing the funds (e.g., the Federal government in the U.S.);

e) If capital costs end up being higher than predicted, they may discourage completing the project as originally designed, and hence may leave parts of the system unbuilt; this may, in turn, reduce the initially intended function or functions of the system, decreasing its use, reducing revenues, and generating additional pressures on the operating agency;

f) In more general terms, underestimation of either capital or operating costs tarnishes the image of the system (e.g., perception of poor management practices), decreases its marketability, and discredits the planning process; all these factors may jeopardize subsequent project proposals;

g) Finally, underestimation, and the subsequent cost overruns, may

---

5 One of the most difficult questions confronting the cost estimator is how to understand and estimate possible changes in costs due to inflation or escalation. Inflation is the time-oriented increase in costs brought about by rising prices of materials, parts, goods, services, etc., due to mismatches between their supply and the money available to acquire them. Escalation is the time-oriented increase in costs brought about by increases in the amount of resources (e.g., labor, materials, or services) required to complete a project. It may also be caused by the continuous modification or upgrading of a project output beyond the planned specifications. (Stewart [1982], pp. 223-239.)

6 Deiter [1985].
embarrass the feats of the people that had supported the proclaimed estimates, possibly causing adverse effects in the evaluation of their particular accomplishments (e.g., for a politician, cost overruns may funnel an electoral defeat).

Some authors argue that if capital costs were accurately calculated, there would be less incentive for cost control (i.e., if the estimates are closer to actual figures, the constructor will go close to those estimates and then end up spending more than if costs are said to be lower), which in turn would generate more expensive projects. Therefore, underestimation encourages more stringent cost control practices. These authors further state that if the true price of some projects had been known in advance, these project would have never been undertaken and this would have been detrimental to society's economic well-being, since their benefits have, ultimately, outweighed the costs (even when these costs have ended up being much higher than expected).

The argument about cost control, however, does not apply to the concerns raised in this thesis. During the planning phase of a project, the decision maker has to decide which alternative to pursue. Therefore,

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7 See for instance, Merewitz [1972]. This author, based on a regression analysis of several public works projects, found that cost overruns were positively related to size of project, incompleteness of preliminary surveys, engineering uncertainty, inflation, project scope enlargement, length of time to complete project, exogenous delays, complexity of administrative structure, and inexperience of administrative personnel. He further divides them between controllable and uncontrollable overruns. Among the former, he identifies poor administration, and incomplete starting surveys of engineering, financial, and legal problems. Among the latter, he distinguishes inflation, that he rates uncontrollable but often foreseeable, and scope changes due to unexpected technological problems or construction delays due to unanticipated causes, such as wars, new laws, or strikes.
the immediate purpose of the estimation process is not the construction of the transportation facility (that may come later) but rather the selection of the best or preferred alternative among several (although, of course, the selection of the preferred alternative may be influenced by what the possibilities of constructing one or another alternative are). If estimates are biased, the decision will be made, in principle, on the wrong basis, regardless of the consequences at the time of construction. Also, at the time of selecting alternatives, commitments are made between different institutional levels in terms of dividing funding responsibilities, and this would likely be based on capital and operating costs. Finally, lack of accuracy in estimating costs would ultimately affect the bidding process; if estimates are incorrect, the bidding process may be distorted, adding frictions between contractors and administrators during the construction of the project.

The argument about missing the opportunity to construct public works projects is also debatable since the blame, in those cases, would be put on benefit estimating rather than cost estimating, for final benefits are the ones that are argued to be underestimated. In the end, all these arguments can be consolidated into two, considering what the particular actor (e.g., the decision maker) perceives as most important from society's perspective: (a) to perform an unbiased selection process or (b) to underestimate costs (or overestimate benefits) with the aim at keeping ultimate costs low (or

---
8 For instance, in the U.S., the Urban Mass Transportation Administration looks at, among other criteria, the financial commitments at the local level and the operating effort to decide to go ahead with a project. Therefore, if capital costs are underestimated, the financial commitment at the local level will appear higher; if operating costs are underestimated, the operating effort will appear good.
at reflecting the perception that ultimately benefits always turn out to be larger) even if the selected alternative is not the "best" alternative ("best" on the basis of unbiased information and society's preferences). This thesis follows the former.

In addition to capital costs, operating costs should also be carefully calculated and reliable revenue sources pinpointed, so that operating deficits do not become burdensome to local institutions. Ideally, the purpose of accurate operating costs is to ensure that a transit system is not built if local governments cannot afford to operate it (considering the extent to which the local political process establishes that operating deficits are adequate). The sources of revenue must be sufficient to pay not only those operation and maintenance costs generated by the operation of the system and not covered by revenues or contributions from the different levels of government, but also the local share of the principal and the interest on any bonds issued to pay for the capital costs.

Table 1.1 highlights the differences between the estimated and actual capital costs for various projects undertaken during the past decade in the United States. The actual numbers are adjusted for the purposes of comparison to the year when the study was undertaken and costs were estimated. The average building cost index for major U.S. metropolitan areas (as reported in Engineering News Record was the indicator used for the adjustment. Since annual outlays were not readily available, total project expenditures were adjusted by the change in the appropriate building cost index considering that expenditures incurred in the same fashion as funds provided by the federal government. Percent changes vary from almost 12% in the case of Miami's heavy rail system to 77% in the case
Table 1.1
Estimated and Actual Construction Costs per Mile
Selected Cities and Technologies

<table>
<thead>
<tr>
<th>City</th>
<th>Corridor</th>
<th>Mode</th>
<th>Construct. costs (millions of dollars per mile)</th>
<th>Actual mill.'s $ per mile</th>
<th>Adjust. to Change (percent)</th>
<th>Change ((c-a)/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Estimated (a) (year)</td>
<td>Actual (b) (year)</td>
<td>(c)</td>
<td>((c-a)/a)</td>
</tr>
<tr>
<td>Buffalo</td>
<td>LRT</td>
<td></td>
<td>$33.28 (74)</td>
<td>$82.66 (85)</td>
<td>$50.26</td>
<td>51.0%</td>
</tr>
<tr>
<td>Sacramento</td>
<td>Northeast LRT</td>
<td></td>
<td>$4.75 (80)</td>
<td>$9.62 (86)</td>
<td>$7.77</td>
<td>63.4%</td>
</tr>
<tr>
<td>Santa Clara Guadalupe</td>
<td>LRT</td>
<td></td>
<td>$13.80 (81)</td>
<td>$28.00 (88)</td>
<td>$24.02</td>
<td>74.0%</td>
</tr>
<tr>
<td>Atlanta</td>
<td>A, B, &amp; C HRT</td>
<td></td>
<td>$51.34 (73)</td>
<td>$93.28 (86)</td>
<td>$64.28</td>
<td>25.2%</td>
</tr>
<tr>
<td>Baltimore</td>
<td>A &amp; B HRT</td>
<td></td>
<td>$32.14 (73)</td>
<td>$70.71 (87)</td>
<td>$48.17</td>
<td>49.9%</td>
</tr>
<tr>
<td>Miami</td>
<td>HRT</td>
<td></td>
<td>$39.75 (78)</td>
<td>$52.50 (84)</td>
<td>$44.42</td>
<td>11.8%</td>
</tr>
<tr>
<td>Detroit</td>
<td>DPM</td>
<td></td>
<td>$41.03 (85)</td>
<td>$72.41 (87)</td>
<td>$70.66</td>
<td>72.2%</td>
</tr>
<tr>
<td>Miami</td>
<td>DPM</td>
<td></td>
<td>$41.05 (83)</td>
<td>$73.68 (86)</td>
<td>$72.65</td>
<td>77.0%</td>
</tr>
</tbody>
</table>

Note: The sharp differences among systems with similar technologies is mainly due to the different physical requirements involved (e.g. an underground system costs more than a similar one at grade).

Sources: UMTA, February 1988.
Key: HRT - Heavy Rapid Transit, LRT - Light Rail Transit, DPM - Downtown People Mover
Own calculations

of Miami's people mover. These changes -- which include all kind of causes from changes in project scope to those produced by unforeseen inflation -- indicate a sizeable underestimation of costs for transit projects carried out in the last decade in the United States.

Table 1.2 indicates the cost estimates at several different times for a transit line in Buffalo, New York. The numbers are in current dollars and constant dollars. Some of the reasons alleged for the changes in cost estimates are provided. Adjustments are made upward along the way to

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9 A more detailed discussion of the Buffalo case study will be developed in chapter 4.
### Table 1.2
Capital Cost Estimates for Buffalo Metro Rail

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Niagara Frontier Mass Transit Study (1971)</td>
<td>11-mile HRT</td>
<td>$241</td>
<td>Estimate based on predominantly aerial alignment.</td>
<td></td>
</tr>
<tr>
<td>Buffalo-Amherst Metro Preliminary Design (1974)</td>
<td>11-mile HRT</td>
<td>$476</td>
<td>$375</td>
<td>HRT Increase due to inflation, 80% increase in underground and refined engineering.</td>
</tr>
<tr>
<td></td>
<td>6.4-mile LRT</td>
<td>$213</td>
<td>$168</td>
<td></td>
</tr>
<tr>
<td>Alternatives Analysis/UMTA Grant Application (1976)</td>
<td>11-mile HRT</td>
<td>$555</td>
<td>$370</td>
<td>Based on escalated unit costs of 1974 estimate by taking into account different technologies.</td>
</tr>
<tr>
<td></td>
<td>6.4-mile LRRT</td>
<td>$336</td>
<td>$224</td>
<td></td>
</tr>
<tr>
<td>Ridership and Operations Analysis/ Full Funding Contract (1978)</td>
<td>6.4-mile LRRT</td>
<td>$450</td>
<td>$255</td>
<td>Refined estimates; engineering changes; schedule revised; target date for revenue service; increased contingencies &amp; insurance.</td>
</tr>
<tr>
<td>Forecast Update (1985)</td>
<td>6.4-mile LRRT</td>
<td>$525</td>
<td>$253 *</td>
<td>New estimate near completion of project; a phased-out station was reinstated.</td>
</tr>
<tr>
<td>Forecast Update/ Cost to Complete Estimate (1987)</td>
<td>6.4-mile LRRT</td>
<td>$552</td>
<td>$264 *</td>
<td>Unanticipated inflation; utility relocation costs; start-up costs; claims settlements; station artwork.</td>
</tr>
</tbody>
</table>

Note: The constant-dollar column was calculated using the average building cost index for major metropolitan areas in the U.S. as reported in *Engineering News Record*.

* These values were calculated assuming costs took place in a schedule similar to the disbursement of federal funds.

Key: HRT - Heavy Rail Transit  LRT - Light Rail Transit  LRRT - Light Rail Rapid Transit

Sources: Niagara Frontier Transportation Authority, May 1987; Engineering News Record (various issues); and own calculations.
reflect design changes or "unpredictable" additional costs. The question that this table raises is: would decision makers have selected the same alternative, had they known in advance the actual costs for undertaking the selected alternative? Another question is: why were initial costs so much lower than final costs.

In recent years, a lot of attention has been focused on the performance of existing urban transit systems and the impact of the construction of new ones or extensions of existing ones. Most of these systems have not lived up to their expectations, with projected ridership levels usually overestimated and capital and operating costs underestimated. These disappointments have tarnished the image of transit systems and have put additional pressure on accountability and managerial performance.

The gaps between planning estimates (the costs that are finally calculated during preliminary engineering and final design) and those that result after the construction of the transportation facility have attracted the attention of public institutions, which are now trying to tackle the issue. For instance, in the United States, the Urban Mass Transportation Administration (UMTA) has issued a series of guidelines trying to improve and control the development of the process of analyzing transit

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10 The problem of underestimating costs has been highlighted as one of the six critical topics that deserve further attention to strengthen the alternatives analysis process by a panel convened by the National Cooperative Transit Research Program of the Transportation Research Board to discuss the area of alternatives analysis (conversation with the chairman of the panel, Prof. Michael Meyer, on February 5, 1987).
1.3. Scope of the Research

As mentioned in the introductory section, the thesis will focus on cost estimating within the process of analyzing alternatives in transportation planning. The alternatives that are analyzed will encompass projects involving fixed-guideway transit systems (e.g., new rail lines, extensions of existing lines, and busways).

The process of analyzing alternatives comes after the system planning phase during which the particular transportation problems in the (metropolitan) area are identified along with the study corridor. Alternative solutions are proposed for the corridor and subsequently analyzed in order to select the "best" one. The process of analyzing alternatives is, then, the critical stage during which planning must be carried out at a level of detail deep enough to select the "best" alternative. It is in this step that pressures from interested parties reach the highest point and decisions are most crucial. The development of the process of alternatives analysis reflects the complexities of the urban transportation planning process and its interdisciplinary nature.

The thesis focuses on the alternatives analysis process, as it is

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11 Ryan, J.M., et.al. [1986]; National Cooperative Transit Research and Development Program [1983]; and Urban Mass Transportation Administration [1980]. Presently, UMTA is in the process of reviewing a new draft of guidelines reflecting comments and suggestions from previous planning experiences.

12 In the U.S., the outcome of the process of analyzing alternatives is called the "locally preferred alternative report." This is the alternative that if approved by federal government (specifically, the Urban Mass Transportation Administration), will be carried into the preliminary engineering phase, and then final design and construction.
understood in the United States, for several reasons. This process involves fixed-guideway systems -- i.e., heavy rail, commuter rail, light rail, or busways -- which have a permanence not present in other transit systems, such as bus or paratransit systems. In fixed-guideway systems, the question of aging facilities, and the impact of the construction of new systems or extension of existing ones have a higher relevance than in other less permanent systems. Furthermore, spending levels for the construction, maintenance, and operation are usually higher, putting more pressure on the management and planning of this type of transit systems.

In considering the definition of "costs," the thesis focuses on (a) capital costs (i.e., engineering, right-of-way, construction, vehicles, equipment, and other facilities), (b) operating costs over an extended period of time (including indirect costs such as administrative, overhead, taxes and insurance), (c) financing costs (e.g., debt service on bonds or short-term borrowing, and special financing fees), and (d) maintenance and repair costs over an extended period of time. (The last three groups of costs (b,c, and d) will be put, for convenience, under the rubric of operating costs unless there exists a need for further clarification.) This list is by no means clear cut since there is no agreement among academics and practitioners about what items should be included under transit system costs. The empirical investigation of several cases will help to recognize which costs are usually considered and which are not and why.

These types of costs, compared to less "tangible" costs, such as travel costs or environmental costs, are expected to be more manageable, more objective, and probably less conducive to influence by interested
parties. There are precise methods and techniques to calculate capital and operating costs. Estimators with adequate technical backgrounds are hired by estimating departments for the sole purpose of calculating capital and operating costs. Hence, decision-makers can be presented with a straightforward analysis, on the basis of which decisions should be less "malleable" and more "accurate" than in areas with more controversial information. This should help isolate the issues from too many interferences and reach more general conclusions.

Lastly, cost information is often an extremely important basis for making a decision about project investments; it may be the primary determinant for such decision. Even when the final decision is not based on cost information, this information for preliminary proposals is often the major determinant in deciding whether to pursue the project further. Key evaluation criteria used in many studies to select a short list of final alternatives include ridership, cost (capital and annualized), and cost effectiveness measures (annualized cost per new rider and annualized cost per passenger mile)\(^{13}\).

Cost estimation cannot be investigated and understood without looking

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\(^{13}\) For instance, Niagara Frontier Transportation Authority, Alan Voorhees & Associates, Inc. [1976]. This report indicates that the two areas of overriding relevance (among the several dimensions of transit alternatives) are cost and level of service provided (pages 4 and 5). Capital cost is crucial in any study of lower capital cost alternatives. Operating cost is, in combination with capital costs, the critical element in the evaluation of the cost-effectiveness of alternative systems. Also, Urban Mass Transportation Administration [1984], and Ryan, J.M., Emerson, D.J., et. al. [1986] in the new guidelines for UMTA's alternatives analysis, indicate how one of the thresholds to approve study funds, and subsequently preliminary engineering and construction, is an index reflecting the ratio of capital and operating costs minus travel savings by new transit riders.
at the broader picture of the transportation planning process. Some elements of this process, particularly demand estimation, considerably affect costs. These elements must be kept in mind when investigating the process of estimating costs. By focusing on costs but looking at the broader planning process, one should be able to identify both the issues that particularly pertain to the cost estimating process and those that are more general and applied to other elements of the planning activity and their interactions.

1.4. Research Methodology

The approach taken in this thesis relies upon the investigation of several case studies. The case study approach focuses upon particular cases, and then generalizes conclusions and observations after an in-depth understanding of these cases. In the first stage, the research looks into secondary sources that help define the broader frame of reference and the evolution of the research in the topic. In the second stage, the research focuses on an ongoing alternatives analysis process for a fixed guideway system in the South Shore corridor of the Boston metropolitan area. This case is complemented with two more cases from other cities in the United States. Finally, cases from other parts of the world are investigated to draw the final conclusions of the thesis. These cases from abroad bring a comparative perspective to the study and allow one to determine other variables of interest.

The basic data gathering techniques in this study were detailed field interviews supplemented by examination of documents (proposals, reports, etc.) and periodic literature (journals, newspapers, etc.). Appendix A
includes the list of institutions and individuals interviewed; appendix B shows the list of the technical bibliography and documents examined.

The interviews were conducted with as many people associated with a project as possible. In all the cases, interviews were held with the managers of the transportation projects. In addition, other interviews were held with the consultants involved in the project and the decision makers. Decision makers included individuals from several decision-making levels: municipal officials, members of advisory and control boards, managers of the metropolitan transportation authorities, and elected state officials. Another set of interviews involved people from those levels of government involved in approving funds for the construction of the projects. In the U.S., these interviews involved federal officials at the Urban Mass Transportation Administration, and regional administrators of this same federal agency. A number of key people that had opinions on the projects, although they did not participate in them directly, were interviewed as well. For the cases abroad, the author participated thoroughly in one (La Paz, Bolivia) and partially in the other (Madrid, Spain).

The information obtained from each case fell into three main categories: information concerning the technical and decision-making processes, information concerning the technical elements of the analysis, and information concerning the people involved in both the technical and decision-making processes.

The case studies were selected to include several different technical, institutional, and political environments, although with some common basis for comparison. The criteria for the selection of the case studies
included: (a) a recent (no more than ten years old) or ongoing process; (b) similar levels of investment; (c) different outcomes (in choice of technology); (d) for the cases abroad, a planning process representing a stage similar to the alternatives analysis process in the United States, with several alternatives considered at the beginning of that process and the need to choose among them; and (e) availability of information.

The research is carried out along two major dimensions: technical and decision-making. The technical dimension is examined through an analysis of the components and approaches of cost estimating, and the issues of database management, uncertainty, phasing of alternatives, and organizational setup. The decision-making dimension is examined through the identification and investigation of the behavior of the actors (individuals and institutions) involved in the cost-estimation process, and the analysis of the attributes of the decision-making process including stages of the process, types of problems, uncertainty of the decision, and role of estimating.

The connection between both processes is examined through attributes such as: the timing of costs analyses and its relation to the development of the decision-making process, the action orientation of cost estimates (e.g., the actions that may be eventually taken after a particular set of cost estimates is generated), the communication and interaction between analysts and decision makers, the influences from the political dimension, the validity of the technical process (including data gathering, interpretation and quality of cost data, and evaluation of cost models), and openness and transparency of the cost estimating process (as closed studies could be affected by the value judgments of the analysts and
decision-makers) \(^{14}\). Several of these dimensions are further assessed through the investigation of database management techniques and the possible improvements that computer-based information systems could bring to the effectiveness of decision making, the performance of sensitivity analyses, and the generation of more systematic ways of obtaining the "optimal" solution \(^{15}\).

A study such as this risks overlooking or neglecting some issues and elements. The transportation planning process, with its myriad of components and interests (more on this in chapter 2), is influenced by numerous factors that may affect its final outcome (i.e., the transportation facility constructed). The diversity of the case studies tries to encompass as much variance as possible to identify the major variables that influence the cost estimating process. There are, however, other perspectives such as the macro-administrative structure (e.g., a centralized versus a decentralized approach to estimating costs), or a post-management analysis (e.g., how construction took place), or differences in the maturity of the project (e.g., how new the project and technology were), that were not followed. Instead, this thesis looks at the history of the planning of the transportation alternatives from the perspective of the actors involved in the process. This process-oriented perspective is shaped by the actors' technical contribution or their personal or political stakes in the construction -- or not construction -- of the project. Chapter 2 further develops the general theoretical framework that guides this process-oriented perspective.

\(^{14}\) Tanaka [1982].

\(^{15}\) Date [1986]; Senn [1984]; Keen [1981].
Within the process-oriented perspective, there are some elements which are difficult to isolate and identify. For instance, people in charge of carrying out the technical process are seldom ready to accept that more emphasis and work are put into a potentially "preselected" alternative with other alternatives being overlooked and probably put into a disadvantaged evaluative position; that preliminary cost estimates were possibly done carelessly and with too much optimism; or that perhaps initial preferences affected which data they used and how they undertook the technical process. Some of these components therefore need a careful but unavoidably personal perception that may be subject to criticism. This task is accomplished through questioning of as many different people as possible (different in the sense of having different stakes in the process) and scrutinizing documents and newspapers.

1.5. Summary and Conclusion

The underestimation of capital and operating costs in the analysis of urban public transportation alternatives has been highlighted as one of the critical points in the transportation planning process that requires further investigation. A reliable estimate of the costs of constructing, operating and maintaining each alternative is crucial to an accurate assessment of its cost-effectiveness and financial implications, and hence of its evaluation vis-a-vis other alternatives.

The purpose of this thesis is to understand why the underestimation process occurs so often and conclude with an assessment of the degree to which technical work actually contributes to informed decision making. The research will develop a framework for the estimation of capital and
operating costs including two major dimensions and their components: the
technical dimension, with the definition of its inputs, models, and
outputs; and the decision-making dimension, with the definition of the
actors, organizations, their relationships, and the political pressures
that come from external forces and interest groups trying to force desired
outcomes. The research methodology consists of a case study approach with
one initial case in Boston, two more in the United States, and two more
from abroad. The diversity of the cases helps one to better perceive and
define the different components of the framework and to reach a better
collection to the ultimate objective of the thesis: the definition of the
role of technical analysis in the decision-making process.
2. TRANSPORTATION PLANNING IN A CHANGING ENVIRONMENT

2.1. A Brief History of Transportation Planning

The history of transportation planning for the last forty years has been one of a continuous and dramatic change in its conceptual and methodological focus. The 1940's saw the beginning of the development of models that tried to replicate the relationships between land use and transportation. Out of these efforts, the sequential demand model was developed. At that moment, transportation planners were mostly concerned with ways to increase the mobility of the population, and expansion of highway capacity was usually the recommended solution.

By the end of the 1960's, due in large part to the lack of attention given to the urban environment, the public reacted against the construction of urban expressways and thus precipitated a re-examination of transportation methods and policies. In the early 1970's, the external impact of transportation facilities became a significant planning issue. The objectives of transportation planning, previously expressed mostly in operational terms, began to be expressed in terms of more general criteria including environmental and social factors (e.g., special services to the elderly and handicapped, energy, safety, and equity considerations).

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16 The sequential demand model was a departure from the common demand models consisting of a single equation. It consisted of a number of separate models used sequentially: land-use forecasting, trip generation, trip distribution, modal choice, and traffic assignment. See for instance, Meyer and Miller [1984], or Morlok [1978], pp. 422-447.

17 Menendez [1987], Allen [1987].

18 Menendez [1987]; Altshuler, et. al. [1979]; Gakenheimer [1976].
addition, public transit was perceived as a more valid solution to the urban transportation problem. The type of project implemented was no longer dominated by the capital-intensive, large-scale facility, but tended to rely more on small-scale, operational improvements. This era also meant an increase in the role of central governments -- the Federal government, in the U.S. -- in transit investment and operations. In the U.S., the federal involvement encouraged the planning of a high number of fixed-guideway transit systems to be constructed in part with Federal funds.

In the 1980's, the changes in central government policies (fiscal federalism), along with the failure of some of the transit systems in achieving their expected objectives, have led to a deeper scrutiny of the generation of transit plans and of the activities of transit agencies, as well as an emphasis on accountability. In addition, the participation of private transit providers is being stressed as a way to help improve the transportation problems in urban environments. This continuous change in focus of transportation planning has produced, for 40 years, parallel changes in the procedures and objectives of the relevant organizations.

Out of this new environment, a new attempt in the 1980's was made to re-establish a role for long-term transport planning after the period of reaction against the inadequacies of conventional forecasting model had led, particularly in the US and UK, to an increasing emphasis on short-term transport planning measures. This attempt led to the development of a

19 The short-range, operational planning was called "Transportation System Management," (or TSM) in the U.S.. See Gakenheimer and Meyer [1979] for an account of its emergence.

20 UMTA was established within DOT in 1968.
strategic framework that acknowledges the changing environment surrounding the transportation planning process, emphasizes the action orientation of plans, and redefines the role of government in providing public transportation services \(^\text{21}\). This framework underscores the organization as the focus of transportation plans, and the need to define its role. In addition, the framework shifts the focus of the planning process by emphasizing the strategic consequences of its outcomes.

This brief historical review illustrates how transit plans and policies have been subjected to the wandering and erratic pressures of national and urban politics and the interest groups that shape transportation policy. The result has been a broadening of the goals that mass transit must accomplish and a confusion as to what mass transit is supposed to do to achieve those goals. All this has been reflected in the planning process. By attempting to achieve so many goals, transit planning has not been able to focus on a clear methodology but rather has put that methodology at the mercy of the political environment.

### 2.2. The Process of Analyzing Alternatives in Transit Project Planning

Before getting into a more detailed description of the case studies and the technical and decision-making processes in the next three chapters, this section first summarizes the prevalent approach in the planning of major transit facilities. It then briefly describes the major elements of the process of analyzing alternatives as one of the major components of

\(^{21}\) See for instance, Friend and Hickling [1988]; Bryson and Roering [1987]; Kaufman and Jacobs [1987]; Nutt and Backoff [1987]; Tomazinis [1985]; and Lloyd and Meyer [1984].
transit planning.

The development process for major transit investment projects, within which local institutions plan and develop fixed guideway transit facilities, contains five steps from project conception to construction: system planning, analysis of alternatives, preliminary engineering, final design, and construction. During the system planning phase, local agencies examine long range urban development trends, collect travel data, forecast needs, and evaluate transportation policies and investment options. Based on their preliminary assessments of travel patterns and problems, local agencies evaluate a range of alternatives leading to the identification of those that seem to merit further study based on their cost-effectiveness, financial feasibility, or other more general criteria. These alternatives are then studied in detail during alternatives analysis, leading to the selection of the locally preferred alternative in terms of both mode and alignment. This alternative is then further examined during preliminary engineering and final design prior to its construction.

The process of analyzing alternatives focuses on a specific transportation need (singled out during the system planning phase), identifies alternative actions to address this need, and generates the information needed to select an option for implementation. In many respects, the step of analyzing alternatives is the key step in project

\[22\] These five steps are required in the U.S. In other countries the extent and scope of these steps may vary. (In transportation planning, U.S. approaches have usually been followed in other countries a few years later. This has been the case since the 60's when the pressure to plan highway construction accelerated transportation methodological innovation in the U.S.). Nevertheless, since the U.S. approach constitutes an adequate framework to explain and understand the different steps of the process, its terminology is used in this section without loss of generality.
development since the selection of a project initiates the process that will eventually lead to its construction along with the improvements that it will bring about, the costs that will be incurred, and the environmental consequences that will result.

As a response to a perceived need -- politically or technically motivated -- a local agency investigates the priority corridor in detail and singles out alternative solutions to the transportation problems identified for the corridor. The range of alternatives typically include one or more rail options -- which may range from light to heavy rail technologies --, a busway alternative, and a transportation system management (TSM) alternative that represents the best that can be done without a major investment in new infrastructure. Sometimes, an alternative consisting of a somewhat novel technology is also included.

The realization of the technical process requires a wide range of skills, including travel demand forecasting, estimation of capital and operating costs, analysis of social, economic, and environmental impacts, financial analysis, and evaluation. These skills may not be present in a single local or metropolitan agency. In the U.S., for instance, the metropolitan planning organization is skillful in travel demand and land development analyses, but the transit operator may have greater expertise in transit operations, project design, cost estimation, and financial analysis. Either or both may have project management ability. The necessary blend of technical skills obliges the cooperation of several agencies and/or consulting firms working under the supervision and management of a lead agency -- usually a local or metropolitan agency closer to the local decision-makers and with the capability of managing the
project and supervising its construction if this step is reached. For instance, in the U.S., many different kinds of agencies have served as the local lead for federal-sponsored transit planning projects. These have included transit operators, metropolitan planning organizations, agencies of city government (e.g., departments of public works), state highway and transportation departments, and regional port authorities.  

The perceived need and the identification of alternative solutions initiates the study process and the definition of the participating agencies, their roles, and responsibilities. These agencies agree on the purposes to be achieved with the transportation facility, the issues to be addressed in the study, the boundaries of the study (i.e., what will be investigated), and which data and models will be used for addressing the purposes and issues of the study. In principle, the attempt is to develop a set of analytical methodologies and a set of alternatives for analysis which all the participants agree on, before the more detailed technical analysis is undertaken. Once the agreement is reached, the responsible agencies carry out the bulk of the technical analysis including the forecasting of demand, the estimation of capital and operating costs, and the assessment of potential funding sources. The different pieces will be put together into a document -- in the U.S., the Draft Environmental Impact Statement (DEIS) -- that is subject to analysis by other potentially

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23 Ryan, et. al., [1986].

24 This process is called "scoping process" in the U.S. Although, in principle, it is a process to be accomplished at the beginning of the planning study, it usually ends up redefining itself as priorities shift, interested parties are added to the process, etc. In the scoping stage, the attempt is to define the terms of reference for the rest of the planning exercise.
interested institutions and the public at large. This step ensures public participation in the decision making process. Out of this process, one alternative will be selected for more detailed study and, if funds are secured, eventual construction.

Higher levels of government provide funding and technical assistance during some or all of the steps of the technical process. These levels of government, at key points, review the local technical work for completeness and accuracy, and acknowledge the methods being used and the results obtained. Between each pair of phases there are decision points, at which time the relevant agencies decide whether to support the continuation of the planning and project development process. Cost-effectiveness, financial feasibility (compared to other alternatives), and local financial effort (i.e., strength of the proposed capital financing plan including provisions to fund potential project cost overruns, and stability and reliability of sources of operating deficit funding) are major considerations at these decision points.

In principle, the purpose of the process of analyzing alternatives is to develop sound and objective information necessary for informed project decision making. Among other things, project decisions (i.e., which option will be the preferred alternative) are based upon realistic cost estimates and financing proposals that take into account the operating expenses of the proposed transit system. The estimating process is

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25 In the U.S., after the public participation process, a new document, the Final Environmental Impact Statement (FEIS), is published including those changes deemed appropriate based on the comments gathered during that participation process.

26 Meyer and Miller [1984].
therefore crucial. The estimated values for the different variables and particularly capital and operating costs may tilt the balance towards one alternative or another. At the same time, the technical process is not performed at sufficient detail to recognize all the necessary engineering and environmental conditions that may affect the project. There is a tradeoff between comprehensiveness and how much can be accomplished. At this stage, only preliminary work is done in the field (to estimate slopes, types of soils, or how many trees must be torn down). Most of the work is performed in an office, based on maps and other cartographic information. Decisions therefore are prone to be controversial and the political process reaches its peak. Political actors and interest groups try to influence the development of the planning process and its results to reflect their points of view on how to address the particular transportation problem.

Figure 2.1 schematically summarizes the different steps of the process that leads to deciding which alternative to pursue. The figure illustrates how decisions made about how to undertake the planning process, which alternatives to consider and which techniques to apply may all ultimately affect the selection of the preferred alternative. The range of alternatives could theoretically be very large, but the constraints of the technical process, in terms of how much it would cost and how long it would take to accomplish it, limit the possibilities to consideration of half-a-dozen alternatives (or a few more that are variations of the six basic ones). Transportation planners must then analyze that set of alternatives and present the pros and cons of each alternative according to a variety of criteria.

This process is fairly formalized in some countries -- for instance,
Figure 2.1
Schematic Representation of the Alternatives Analysis Process

- Preliminary initiatives for solutions in corridor
- Composition of group that makes decisions
- External forces and interest groups
- Formation of study techniques: scoping process. Roles and responsibilities are defined (public agencies, consultants, etc), issues are identified, availability of data and models are determined.
- Options for study: further definition of alternatives and methods to be used in the analysis. Agreement with methodologies and other aspects such as timing, revisions, information, O-D flows, costs, uncertainty, etc.
- Main technical study: development of conceptual engineering and assessment of impacts. Demand model, estimation of capital and operating costs, identification of potential funding sources, evaluation, etc.
- Preparation of final report and selection of preferred alternative
in the U.S. -- and more of an ad-hoc nature in others. The differences among countries stem from a variety of factors, ranging from the cultural environment, to the participatory tradition of the society, to the influence of the central government, and to the assumed role of transit in the urban transportation system. In the U.S., the American tradition of politics and district representation fosters a process with a significant level of citizen participation. However, in some areas -- particularly in the West -- transit faces an often inhospitable environment.

In spite of the differences in planning cultures, the basic purpose of the transit planning process remains the same: the identification of which among several alternatives seems to be the more appropriate transit solution to address the transportation problems of a corridor.

2.3. The Characteristics of the Transportation Planning Environment

The transportation planning process is an endeavor that involves many individuals and institutions. This broad appeal mainly comes from two directions. First, individuals are concerned about the effects of the construction of permanent, large transportation facilities and the burden on their budgets as taxpayers and as consumers of transportation services. Second, decision makers need to mobilize a large enough constituency to bring about the construction of large transportation facilities.

Furthermore, the limits of local finances to fund the construction of this kind of facilities forces the involvement of other levels of government with the many more interests gravitating over them. Moreover, the local agencies usually lack the resources to carry out the various elements of
the technical process, and must request the involvement of other levels of
government and private consultant agencies. 27

This institutional framework enlarges the complexity of the
transportation planning process. The high degree of complexity, in both
the technical and decision-making components, evolves from several factors,
such as the uncertainty associated with the impacts of alternatives, the
multiplicity of criteria to evaluate alternatives, and the fuzziness of the
line separating the technical and political processes 28. These factors
affect the different elements of the planning process and, particularly,
the cost estimation process.

Associated with the elements of the planning process at the stage of
analyzing alternatives, is a considerable amount of uncertainty in both
quantitative values and qualitative aspects (such as political
uncertainty). This uncertainty has two edges: on one side, planners would
choose to know everything with certainty so their plans can be based on
facts not on mistaken perceptions; on the other side, uncertainty -- and
its associated ambiguity -- is the critical element that permits the
different actors and audiences in the transportation planning process to
articulate their views and play their particular roles.

There usually are not one but several decision processes in transit
project planning. Due to the geographical and financial scope of the kind

27 Meyer [1978] identifies almost forty different types of actors, at the
federal, state, and local levels, involved in transportation planning
and implementation in the U.S. (page 19, figure 1-1). This
institutional structure, with its myriad of assigned responsibilities
and regulations, has created an "extremely complex environment for
coordinated transportation planning" (page 24).

28 Mahmassani [1984].
of projects that are the subject of this thesis, decision processes spread across both horizontal and vertical layers of government. At the horizontal layer, several local governments may be affected by any of the alternatives being considered (because they cut across their districts), creating some cooperation or competition among the affected constituencies 29. At the vertical layer, the substantial amount of funds that are required to construct fixed-guideway transit projects makes the involvement of higher levels of government (e.g., the federal level) necessary 30. Thus, these transit projects usually involve different audiences which the results of the technical process must address.

2.4. The Broader Theoretical Framework: The Rational Planning Paradigm and its Critics

The complexity of the planning environment has not deterred planners from aspiring to an ideal comprehensive rational process whereby plans are the reflection of a process that (a) is supposed to be impartial (i.e., actors do not deliberately lean the process towards particular outcomes as personal emotions and values stay out of the process), (b) considers all possible alternatives, and (c) concludes selecting the optimal alternative. For over thirty years, this rational paradigm has been the major thrust

29 This aspect is of major importance in the U.S., with its district-representative system and weak metropolitan institutions. Metropolitan transportation projects are more likely to cut across several municipal jurisdictions, generating competing interests which may lead to lack of coordination. The representative system may also encourage pork-barreling and the weak internalization of costs (which tend to be spread over a jurisdiction larger than the represented district).

30 This premise presumes that private construction of this type of projects is usually not feasible for economic, financial, or political reasons.
behind the development of the planning field, and particularly of the transportation planning field, in spite of the fact that criticism of the rational paradigm has been abundant. In reality, however, practicing planners accept the cognitive, practical, and political limitations to comprehensive, rational decision making for planning. They also acknowledge that public decisions are not usually made according to the ideal conception of rationality mentioned above and, consequently, adapt planning methods to the particular characteristics of the situation at hand.

The debate over rationality applies to several steps and components of the planning process. There is technical rationality when methods and data are unbiasedly applied to precisely defined problems (whose definition is also achieved through a rational, scientific process, with all the necessary information and following specific steps). There is also rationality in the decision-making process whereby the decision maker, if one can be identified, bases his/her decisions on all the information available and the maximization of his/her expected utility. In either case, normative rationality would require both comprehensiveness and impartiality. But comprehensiveness cannot be achieved as soon as the

31 De Neufville [1987], Dalton [1986], Alexander [1984], Forester [1984], Allison [1971]. De Neufville [1987] states that one of the major reasons for the pervasiveness of this paradigm include the lack of a persuasive alternative and the fact that education of planners tend to focus on the rational paradigm due to lack of time and resources to expand the curricula to alternative approaches. In the transportation planning field, Gakenheimer [1985], Manheim [1985], Wachs [1985a], and Blanchard [1976], among others, indicate the need to broaden the research agenda in transportation beyond that of the rational paradigm.

32 Forester [1984], Howe [1980].
technical analyst or the decision maker wish to complete the technical study or make a decision within a reasonable period of time and with a reasonable amount of resources. Impartiality is not possible either because the lack of comprehensiveness gives way to uncertainty and ambiguity which allow pressures and, ultimately, compromises between the forces and interests that have a stake in the process and its outcomes.

Besides rationality in both the technical and the decision-making processes, we can also identify rationality in how information flows between those two processes. In principle, the decision maker is the recipient of the information rationally gathered and manipulated (calculated) by the technical analyst. The analyst is an impartial technician, while the decision-maker is engaged in politics, entrusted with expressing public values. Rationality in the link between the technical and decision-making processes implies that information generation and decisions are completely separate and distinct activities. This rationality cannot be achieved because it would not "engage the emotions or imagination of the potential user," 33 probably giving way to plans that are not effective (i.e., plans that do not meet the intended goals).

The attack on the planning paradigm began as early as the 1950's with Simon's discussion of the connection between planning and decision making. He stated that no real decision-making process could meet the requirements of normative rationality: complete information and the simultaneous consideration of all possible alternatives. Almost at the same time, Lindblom developed his concept of disjointed incrementalism. According to this theory, alternatives developed in a planning process differ only

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33 De Neufville [1987].
slightly from the status quo 34. From another perspective, observers of
how planning and administrative decisions were made in the real world
placed increasing emphasis on their political context. That resulted in an
increased sensitivity to the "politics of planning," a resulting critique
of and retreat from comprehensive planning, and the realization that there
is a "culture of planning" that is not necessarily rational 35.

At the same time, organization theorists have suggested that the
institutions and organizations where planning takes place and where
decisions are made do not conform to the premises of the rational model
either. Organizational decision making and behavior may be the result of
bureaucratic politics, organizational "satisficing," or even the simple
limits of individual and institutional attention and information processing
capabilities 36.

These criticisms of the rational paradigm have led several academics
to think that the field of planning theory must confront the question of
how to resolve the contradictions, in practice, between that paradigm and
the realities and constraints of real-life decision-making. Forester
[1984], focusing on the decision-making side, suggests that "[t]he role of
theory may well not be to predict 'what will happen if ...'; instead, (...)[
it] may be to direct the attention of the decision maker, to suggest what
important and significant variables and actors and events and signals to be
alert to, to look for, to take as tips or warnings." Others, focusing more
on the interaction between the analysis and decision-making processes,

34 Lindblom [1959].
35 Alexander [1984].
36 Scott [1981], Allison [1971].
advocate the development of alternative paradigms 37, paradigms that can be labeled under the rubric of social-argumentative paradigm. In this paradigm, one must look at planning primarily as a communicative action rather than mainly as two distinct and separate components: analysis and decision-making 38. This notion provides a useful perspective on the complex interweaving of information, power, and values that characterize planning practice.

The social-argumentative paradigm underscores the impossibility of achieving comprehensiveness (generality) and advocates the understanding of particular events in their own terms and contexts. In this paradigm, the focus shifts to the identification and confrontation of the needs of particular situations rather than to the generation and application of a comprehensive, universal method. The technical process is not guided by an attempt to achieve objectivity -- that is assumed to be an impossible task -- but rather is formulated as part of a broader process wherein concepts, data, and methods evolved as the planning objectives change and the myriad of interests interfere with each other and try to reach agreements on how to proceed. According to this paradigm, the outcome of the planning process becomes "objective" as a result of the interplay of and argumentation among the affected interests and the reliance on a variety of sources, not as a result of a, supposedly, correct method and the analyst's

37 Ines, Judith [1988], page 277; Dutton and Kraemer [1980].

38 Meyer and Miller [1986] follow a parallel paradigm and state that effective planning requires communication with decision makers, providing them with the information they desire and need. The social-argumentative paradigm defines planning in a broader manner as its communicative purpose involves an audience broader than that of decision-makers.
work as a detached observer. Thus, information becomes "more important in problem defining than in problem solving; more in describing process than predicting outcome; more in saying what happened than in saying what works; more in generating alternatives than in comparing them; and more in negotiating than in providing simple decision criteria" 39.

2.5. The Analytical Framework:
A Behavioral Approach to Analyzing the Transit Planning Process

Much has been written about transportation planning methods, their application, and how their results can better reflect actual figures. The literature primarily focuses on analytical elements and possible ways to improve them 40. The drawback is that, although analytical tools are generally available and their improvement and application can be helpful, it is very difficult to explicitly treat the complexities immersed in the urban transportation decision-making process. How effective or how accurate transportation models are cannot be analyzed in isolated technical terms. One must look at the broader transportation planning process including its institutional and political environment.

The disenchantment with transportation planning techniques since the beginning of the 1970s surfaced not so much because of technical errors 41, but rather because of the expectations society put on their role for solving the transportation problems of metropolitan cities and addressing a

39  De Neufville [1987], page 89.

40  Some examples are: Atkins [1987]; Obeng [1985]; Chomitz, et. al. [1984]; Polzin [1984]; Walker [1984]; Caudill, et. al. [1983]; and Merewitz [1972].

41  This is, for instance, the approach taken by Atkins [1987].
myriad of other goals, and the subsequent perception of its failure in solving those problems and achieving those goals. At the end, the success or failure of technical analyses will not depend on the accuracy or the sophistication of their technical components but rather on the ultimate role assigned to these analyses, and how useful they are to make transportation decisions. This is why it becomes crucial to look at the role of transportation planning in decision making and to take a behavioral approach to analyzing the transportation planning process, an approach that focuses on how the technical process is undertaken, how the decision making process unfolds, and how both processes interact with each other 42. In this approach, the transportation analytic process is viewed as a dynamic iterative one, where the analyst, the decision maker, the transportation system manager, the system user, and those affected by the system are all part of the same process or system.

In this direction, the approach followed in this thesis tries to confront the criticisms of the rational paradigm and put them in the right context. Within the rational paradigm, better techniques and more information would unambiguously lead to more accurate estimates and better decisions. If that paradigm, however, does not fit a particular situation (as it seems to be the case in the case of transportation planning), better estimates (or methods to generate more accurate estimates) do not necessarily lead to "better" decisions. This is because underestimation (or even overestimation) may be an acceptable way of hedging against uncertainty, politics, or social preferences. In this vein, the thesis investigates the limits of the rational paradigm through the analysis of

42 Faludi [1987] talks about "procedural" planning.
several transit project planning exercises and, after identifying what leads to underestimation, takes into account those limits to suggest some ways to improve the transit planning process (recognizing that those ways may not necessarily conform to the rational paradigm).

Within the argument-oriented paradigm the technical rational analysis would be understood within a broader framework (than the decision-oriented one), and would attempt to address and explain the complexities of existing planning processes. The argument-oriented approach expands the framework of the planning process by putting more emphasis on the scoping process (i.e., definition of actors, definition of terms of reference, definition of "fair" relative comparisons between alternatives, and definition of set of criteria and/or objectives to evaluate alternatives) considering the possibility of mismatches between decision processes at the local and higher-level institutional settings. This approach does not abandon rational concepts and methods; rather it views these concepts and methods as dealing with other subsystems (institutions, politics, personalities), and hence integrates them into a paradigm that is more encompassing.

By following the argument-oriented approach, this thesis also attempts to illustrate how far the prevalent approach can be from a pure rational process, and then proposes ways to redirect the process in terms of the definition of a "correct" decision-making process. Two complementary approaches can be identified in the literature as normative bases upon which to establish the definition of a "correct" planning process. The first one is to evaluate a "correct" planning process on the basis of overall moral values of fairness, honesty, public spirit, and impartiality.

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43 Etzioni [1988] calls such an approach "codetermination" (page 3).
The second one is to look at how distortions in the process have led to a "planning disaster" in the sense that few or none of its intended goals were achieved. To define a "correct" planning process is no small task, and it will surface several times in other sections of this thesis. For now, we can think that a "good" planning process is such that ensures decisions are made on a good footing -- i.e., on the basis of the best information we can have--, and, to the extent possible, in a democratic way (in the sense that participants have knowledge of the facts and can voice their comments on the technical process). With these conditions, the ultimate purpose of the planning process is to use society's resources in the proper way, anticipating that the eventual implementation of the selected course of action reflects the predicted effects -- i.e., estimated costs and benefits -- and puts no unsurmountable burdens on any affected group or the society as a whole.

Figure 2.2 schematically illustrates the general methodological approach of this thesis. The case studies (empirical framework) allow a view of the transportation planning process from the rational perspective, sustained by the theoretical rational paradigm, and single out those limits that prevent the achievement of rationality. The identified limits allow for a discussion of the elements that comprise a social-argumentative paradigm that expands upon the elements of rational analysis and decision-making theories.

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44 Wachs [1985b], Kelman [1987].

45 See Hall [1980] for the history of some planning failures, in the sense of implementing courses of action that ended up generating the wrong effects and adding heavy burdens to the affected societies.
Figure 2.2
General Methodological Framework

Empirical framework

Transportation planning process (rational process)

Limits of rational process

Proposed framework and operational actions

Theoretical framework

Rational paradigm (analysis and decisions)

Social-communicative-argumentative paradigm

2.6. Summary and Conclusions

This chapter has led to the presentation of the general methodological approach taken in this thesis after a brief description of the history of transportation planning, a discussion of the characteristics of the planning process, and an exposition of both the paradigm upon which the prevalent process is based on and an alternative to it.

The history of transportation planning and the discussion of the characteristics of the planning process support the claim that decision makers typically choose means largely on the basis of a broader set of factors, rather than on the basis of logical-empirical considerations. Drawing on that broader set of factors is then an effective, not a distorted way of making choices and rendering effective decisions.

The claim leads to state the planning process within the realm of a social-argumentative paradigm whereby the researcher can characterize the
planning process with the interrelationships between the technical analysis (information), the constraints and characteristics of the decision-making function (power and politics), and the actors' personal values and beliefs. The social-argumentative paradigm provides crucial insights into the institutional and political factors that shape decisions and influence the technical process.

By designing a framework that makes planners realize the limitations of the rational paradigm, one should be able to generate more "correct" outcomes ("correct" in the sense described in the previous section), or at least a more responsible and reliable planning process. The purpose of this thesis, however, is not to abandon or substitute the prevailing rational paradigm; indeed, much of what it has contributed can well be integrated into a more encompassing paradigm. Rather, it proposes a framework that attempts to better serve the realities of the decision process with a planning process that is strengthened with methods that should encourage improved cost estimation procedures.

In the next three chapters, following the social-argumentative approach, the thesis seeks to explain what has happened in several transit project planning exercises. The discussion is complemented with an analysis of the roles of data (information) in the decision-making process (e.g., communication, justification of previously-made decisions, framing discussions, etc.).
3. CASE STUDIES

3.1. Introduction

This chapter summarizes both the information gathered from interviews held with the parties involved in the different projects and the documentation related to those projects. Each section highlights the main issues related to the estimation of capital and operating costs identified in each case. Chapters 3 and 4 develop these issues with greater detail and put them in the context of cost-estimating and decision-making theory.

All the case studies involve situations where the implementing agencies (the ones in charge of constructing and, eventually, operating the system) did not have the financial capabilities to construct the system. These agencies had to request additional funding from higher level institutions. They involve cases where the proposed system was new or encompassed the extension of an existing facility. In principle, no distinctions are necessary for these two types of projects because the issues discussed in this thesis apply to both types with enough generality. The pressures to select one particular type of technology versus another, however, would probably differ between a new system and the extension of an existing one. In the latter case, continuing with the technology already in place may involve some advantages that are not present in the case of planning a new system.

For each case study, the presentation includes the following sections: (a) a brief description of the geographical context; (b) an introduction to the case study (i.e., what the case is about); (c) a description of the transportation context; (d) a brief description of the institutional
context; (e) a description of the project, projects, or other documentation relevant to the planning and decision making processes for the particular transportation facility, with reference to the cost estimation element of those processes; (f) a discussion of the main issues related to the case study; and (g) comments on the case study.

3.2. U.S. Experiences

Three case studies take place in U.S. cities. The history of some of these case studies spans a long period of time (almost 15 years, or even longer depending on when we consider the first serious proposals began). As a common ground for these three case studies, it is convenient to briefly describe the U.S. context as it relates to transit development.

In the U.S., the study of the history of transit policy and planning (as well as of transportation, in more general terms) is closely linked to changes in broader federal policy. Until the beginning of the 1960's, transit was perceived as a local responsibility with both capital and operating costs to be financed by its users. The social conflicts of the mid-1960’s modified federal policy towards transit which then was presented as an integral part of the new federal commitment to urban renewal and a more 'balanced' transportation system. In 1964, direct capital grants to transit agencies were approved for the first time. During these times privately owned transit firms started to be transferred to public ownership. Operating costs were mostly covered out of the farebox and

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expansion of services was modest 47.

By the early 1970's, the attention shifted to new problems including energy shortages, air pollution, traffic congestion, urban sprawl, and the needs of minority, elderly, and handicapped sectors of the population. The belief that transit was an effective way of serving all these objectives, broadened the political appeal of transit assistance, although transit's direct constituency was relatively small. Transit was perceived as an investment that could address and satisfy many perspectives on the urban problem. This situation led to the authorization in 1974 of Section 5 of the Urban Mass Transportation Act, which provided for direct payments to offset transit operating expenses.

By 1978, the federal government was funding a greater percentage of the total operating and capital subsidy than all other government levels combined 48. In order to gain a broad base of political support for the transit assistance program, new services were expanded and new systems were created in not-so-densely populated areas, where transit could not easily compete with car travel. The transit assistance program became essentially redistributive in nature, with funds flowing from, and back to, local areas on the basis of politically determined criteria (focused on demographics rather than transit service supplied and consumed). These criteria

47 This was in part due to the insulation of the public authority from the day to day politics, so transit services were better tailored to revenues (Fielding [1983a]).

48 Fielding [1983a]. It is ironic, Pucher [1980] indicates, "that in the U.S., with its long tradition of decentralized government, the federal role in transit financing is significantly greater than the corresponding role of national governments in most Western European countries, even with their long traditions of very centralized government structures."
encouraged expansion and the construction of not-so-efficient new transit systems (from a cost-effectiveness standpoint). Social, environmental, and political concerns seemed to govern, rather than costs. None-theless, subsidies reversed the trend of ridership declines of the previous decades, although they promoted less efficiency \(^49\). Transit was given a whole set of social and political objectives, most of them incompatible with operating and financial efficiency.

By the end of the 1970's, there was a general frustration that transit had not been the panacea for urban problems, and had cost too much for what it had accomplished in terms of reducing pollution and congestion, conserving energy, and addressing the needs of particular sectors of the population \(^50\). Attention then shifted from transit's social objectives to the more pressing issue of its escalating costs. President Reagan's policy of "new federalism" emphasized fiscal prudence and accountability, local control and responsibility for expenditures, and increased involvement of the private sector. These policies were to be implemented by phasing out the federal operating assistance program and the provision of funds for new rail construction. At the end of Reagan's presidential mandate, however, the administration had not been successful in implementing these policies.

As a common institutional setting for the three U.S. cases, the Urban Mass Transportation Administration (UMTA) of the federal Department of Transportation plays a major role in all the matters related to urban transit projects that seek federal funds. UMTA has the responsibility for federal funding of planning, capital acquisition, and operating costs for

\(^{49}\) Pickrell [1985]; Fielding [1983b].

\(^{50}\) Hamer [1976]; Altshuler, et. al. [1979].
mass transportation in urban areas. In the projects that it funds, UTMA establishes standards for the planning process and oversees its development. UMTA has regional offices to facilitate the communication between the local participants and the federal office.  

Two major funding sources are provided at the federal level: Section 3 and Section 9 funds. Section 3 are discretionary funds, which the UMTA administrator can allocate as deemed appropriate, while Section 9 are specified by formula. The formula include factors such as the number of bus miles, the population of the area, and the population weighted by population per square mile, for bus systems and revenue vehicle miles, route miles, and passenger miles for rail systems. Section 3 funds and around 60% section 9 funds are used for capital investments, and the rest of section 9 funds are used for operating assistance. Most of the funds for new fixed-guideway systems come from section 3 (discretionary) funds; rail modernization takes about half of both section 3 and section 9 funds combined; the rest is appropriated for bus systems (and a small amount for

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51 At the federal level also, but not directly related to mass transit projects, the Federal Highway Administration is responsible for developing federal policy and procedure guidelines pertaining highway planning and construction. It also funds the design and construction of qualified transportation projects. In addition, the Federal Aviation Administration is responsible for developing federal policy and programs pertaining to air transportation, and for providing funds for airport planning and construction.

52 In 1987, section 3 and section 9 funds comprised 86% of UMTA appropriations for transit systems (equivalent to more than $2.8 billion out of a total of $3.4 billion). Section 3 appropriations amounted to $0.9 billion (27% of the total UMTA grants), while section 9 amounted to $1.9 billion (56%). Information provided by UMTA [April 1988].

53 GAO [1987], pages 246-248.
technical planning purposes)\(^{54}\). Some matching requirements applied to all the funds in such a way that federal match for planning and/or capital assistance cannot exceed 80% of net project costs, or 50% in the case of operating assistance.

For the last fifteen years, there has been a growing shift away from allocating funds in a discretionary manner and towards formula-based allocation. Recently, along the lines of the 'fiscal federalism' philosophy, UMTA officials at the federal and regional level advocated the phasing down of the discretionary portion of UMTA assistance, leaving most of the funding based on formula. This approach, it is argued, would reduce the uncertainty about federal funding and eliminate most of the political component of the transit funding process. The conclusions of this thesis will provide some indications about the appropriateness of this approach in improving the transit planning and allocation process.

3.2.1. The Boston Case Study

Introduction

The Boston case study singularly illustrates the struggle of different parties and institutions over the analysis process as its outcome is taken as the basis for decisions. The struggle forced frequent changes in some of the elements of the planning process such as the alternatives to be considered and the costs to include in each of them. The Boston case also illustrates the difficulties generated by the attempt of the analysis process to satisfy the needs of different audiences as well as those generated by the uncertainty associated with some of the technical

\(^{54}\) Information provided by UMTA [April 1988].
elements, particularly the amount of funding available. These difficulties forced technical analysts to "dress" the project so that compromises could be reached among the different interests involved in the planning process. Finally, because of all these factors, the case illustrates the challenges for decision makers in their efforts to put the project forward.

Boston's transit system is one of the oldest in the United States (its tunnel section is the oldest) and is fairly well developed with a transit network of buses, trolley buses, light rail, rapid rail, and commuter rail transit covering most of the metropolitan area. In the past ten years, the rail network has been in an extensive planning and construction stage as old lines have been extended (Red Line), relocated (Orange Line), or new lines have been proposed (Old Colony Project).

The particular project of investigation in this case study is the Old Colony Project. This project involved the analysis of the rehabilitation of commuter rail service south of Boston's central business district (CBD). Service on the commuter rail line had been abandoned in 1959, due to disagreements over the assessment of operating subsidies and the opening of a major expressway: the Southeast Expressway. (Furthermore, in 1960, a fire destroyed a bridge, over the Neponset River, that connected the rail lines to Boston's CBD, physically eliminating the possibility of using the rail lines for daily commuting.)

At the beginning of the 1980s, the major transportation planning organizations singled out the corridor, the Southeastern portion of Massachusetts, as an area that needed urgent transportation improvements since it was the most rapidly growing area in the state, with a predominant transportation demand toward the CBD of Boston (see figure 3.1). At the
Figure 3.1
Boston's Old Colony Project
time of the project proposal, several major thoroughfares (the Southeast Expressway and Route 3) and a single transit subway line (Red Line from Braintree to Boston) provided the transportation links to the CBD. The area was also served by express buses, a commuter boat service, and feeder buses connecting to the transit line stations and the commuter boat service.

**Institutional Environment**

The agency in charge of managing Boston's transit system is a state agency: the Massachusetts Bay Transportation Authority (MBTA). This agency reports to the State's Department of Transportation, and the director of this department to the governor of the State of Massachusetts. The MBTA, in addition to operating the existing public transportation system, has the statutory responsibility for preparing the engineering and architectural designs for transit development projects and for constructing and operating them within the area constituting the Authority (79 cities and towns).

A variety of other state institutions are also involved in the planning, construction, and management of public transportation in the Boston area. Among them, the Executive Office of Transportation and Construction (EOTC) coordinates the activities and programs of the state transportation agencies, and prepares the capital investment program of the

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55 The subway line, however, extended for a length of 11 miles from South Station and, therefore, did not reach very far along the corridor, with travel lengths of up to 37 miles.

56 The 79 towns contribute to the MBTA budget according to specific assessment procedures. These procedures try to appreciate that the 79 cities and towns of the MBTA District that benefit by the system must share some of the deficit and that a greater portion of the cost of operating the MBTA must come from those cities and towns that get a greater degree of service.
MBTA in conjunction with other transportation programs. The Secretary for Environmental Affairs reviews and approves the programs for the construction of state transportation facilities. Another important state institution is the Massachusetts Department of Public Works (MDPW) which has the responsibility for planning, designing, constructing, and maintaining state highways and their related facilities. At the MBTA, the Advisory Board acts as the regional body in charge of reviewing and approving the MBTA's annual operating budget and mass transportation programs. The Advisory Board consists of the chief administrative officials (or their designees) from each of the 79 member municipalities.

At the local level, the municipal governments have a wide range of statutory powers critical to the implementation of transportation programs such as transit facilities and transportation systems management (TSM) proposals. Any state agency in charge of executing these programs must deal individually with the municipal governments. Local governments have statutory powers regarding land use and zoning, and traffic management and parking within its boundaries on roadways which are not federal, state, or county roadways. In addition, local officials must initiate request for federal urban systems projects in their municipality.

**Project History**

In 1984, as a response to complaints about the unbearable travel congestion in the Southeast corridor voiced by several legislators from districts in the area, the state legislature instructed the MBTA to study the feasibility of restoring commuter rail service in that corridor. The

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57 Each municipality has a weighted vote on the Advisory Board.
study was going to analyze the possible transportation improvements in the area including the rehabilitation for commuter use of the Old Colony lines. In this report, it was stated that "[o]ther possibilities such as light rail or other transit technologies (...) exist but have not been analyzed as part of [the] feasibility assessment." 58 This initial interest in restoring service on the railroad lines gave the posterior studies a suspicious name, 'Old Colony Railroad Rehabilitation Project,' although, as it is explained below, the alternatives also included, initially, a TSM alternative and a busway and, later, a TSM alternative alone.

In response to the state request, a feasibility study was prepared, and it was found that the restoration of the Old Colony service would be feasible (with the adequate physical improvements) at a cost of almost $200 million (in 1984 dollars) for the full-restoration alternative. Following the feasibility study, the governor instructed the MBTA to proceed with the necessary environmental studies, officially launching the initiation of the Old Colony Railroad Rehabilitation Project.

Initially, the environmental studies had to comply only with the state regulations (Massachusetts Environmental Policy Act of 1972) since the project was going to be funded with state funds. The steps included the filing of an Environmental Notification Form, accomplished in January 1986, the preparation of a project scope, issued in October 1986, and the publication of the Environmental Impact Report (EIR). But as local officials approached the federal government and UMTA agreed to provide technical assistance and to consider possible future federal financial participation, the preparation of an Environmental Impact Statement (EIS)

58 Massachusetts Bay Transportation Authority [1984], p. 2-1.
was required, in order to also comply with the National Environmental Policy Act (NEPA) of 1972.

The feasibility study estimated commuter rail capital costs at $187.7 million\textsuperscript{59}, and annual operating costs between $15.7 and $16.8 million for the full service alternative\textsuperscript{60}. Ridership could reach 9,200 passengers per day by 1990. Local newspapers publicized these figures, which became widespread in spite of the fact that the feasibility study explicitly indicated the shortcomings of the cost figure and the elements that were missing (such as land acquisition costs, and provisions for design, administration, and contingency). The figure however was low enough to give the project a head start and a push into the next stage, the process of analyzing alternatives.

By 1985, there were high hopes of returning passenger rail service on the Old Colony lines. For instance, in May 1985, a referendum held in the town of Weymouth indicated that 77\% of the 10,000 people who voted favored the restoration of the commuter rail service, although 53\% disapproved of using local tax dollars to cover operating costs. With this overwhelming support, by the end of the year, the state was hoping to get 80\% of the estimated costs from the federal government and start track work for the

\begin{footnotes}
\item[59] Massachusetts Bay Transportation Authority [1984], table 3.1, page 3-20.
\item[60] The feasibility study also included the possibility of providing commuter rail service only up to Braintree or Quincy Adams where passengers could transfer to subway lines. These options were quickly dropped from further consideration due to strong local opposition in the areas were these stations were located, to the point that later alternatives for the commuter rail system did not even have stops at these stations.
\end{footnotes}
project by 1987. UMTA however was not very receptive because they considered the project a major new capital investment (not a simple rehabilitation undertaking).

Before the formal technical process of analysis of alternatives was initiated, a scoping report was published in September 1986 indicating the range of site-specific and regional-level impacts that would need to be considered in the analysis process. The Secretary of Environmental Affairs had designated the project a "Major and Complicated Project" and appointed an independent body including a wide variety of perspectives and personal and professional interests, the Citizens Advisory Committee (CAC), to review and comment on the technical studies. The CAC basically agreed with the scoping report and emphasized that 'safety and security', 'traffic and parking', 'noise and vibration', 'air quality', 'land use and zoning', 'community disruption', and 'consistency with local plans' were the impact categories that would require particularly detailed analysis in the technical process.

At this initial stage of the process, most of the effort of the project managers was geared towards keeping the alternatives to be considered within the technical limits dictated by federal funding criteria (and, of course, those of the operating agency, the MBTA). For instance,

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61 Most of the track was currently in place (85 percent of the 80 miles), although much of it needed to be upgraded, a new signal system installed, and a new bridge over the Neponset River be constructed. In the Middleborough line, freight service operated in part of that trackage, while passenger service was limited to seasonal service to the Cape Cod area. On the other hand, near the center of the city, with a single track, the provision of passing tracks (to improve reliability of service) was already thought to be costly and time-consuming.

62 Massachusetts Bay Transportation Authority [1986], Appendix.
the relocation of the Greenbush line (with monorail technology, as another alternative) on the median strip of a major route in the area -- Route 3 -- was rejected because that would make the project a 'new start', a qualification that, in federal terms, meant less funds available, stronger competition from other cities in the country, and a lengthier process for approval from the federal government. Federal funds, it was said, would cover only reactivation of existing rail lines 63. In addition, MDPW opposed that alternative on the basis of technical feasibility.

The Route 3 alignment was not the only concern that surfaced from various community meetings. Other dissenting voices were raised in those communities, particularly near the center of the city, through which the trains would pass without making stops. In addition, the proximity of the tracks to some residential areas and particular types of buildings (e.g., schools) started generating fears of neighborhood disruption and destruction.

By the end of April 1987, the price tag for the project had been raised to $387 million. As costs increased 64, the federal government showed less support for the project, and opposition became more vociferous in some sections of the proposed lines. The secretary of EOTC and the MBTA indicated that the project would be phased, starting with the less controversial lines with service only to Braintree station (the terminal

63 At that moment, in 1985, UMTA account for 'new starts' had $368 million, and $411 for 'rail modernization.'

64 One major item in the list of increased costs was the need to reconstruct a bridge over the Neponset river. This bridge had been burnt down shortly after the abandonment of the lines in 1959. Another item was land acquisition costs for station sites and rail rights-of-way.
station on the Red line of the subway system) not to South Station (the initially planned terminal in the Boston CBD).

In spite of the fact that the phasing plan also tried to reflect a $50 million annual spending cap -- the amount the federal government usually allows states to withdraw from all federal transportation funds per year -- the changes angered local legislators and supporters of the restoration for they thought that the state was retreating from its promise of rehabilitating the whole rail system. They demanded a strong commitment from the state to prove that the full system would be eventually put in operation. That came in the form of a request for funds from the governor of Massachusetts. On May 19, 1987, the governor reiterated his firm commitment to the full restoration and requested $195 million from the state legislature over the next two years for commuter rail service serving 34 cities and towns South of Boston (with a total population of around 600,000 persons in 1980) 65.

At that moment, the estimates indicated that the system would carry up to 15,000 passengers a day when open in 1993. The $195 million, if approved by the legislature, would cover 50% of the capital costs for the restoration of the full service. The estimates were based on the calculations made in the Environmental Impact Report (to comply with State

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65 The state request came about as the governor filed a bond issue providing $827 million in direct state support to the MBTA, (twice as much as the $442 million two-year bond issue of 1985). Out of the $827 million, $195 million was allocated to the restoration of the commuter rail service on the South Shore. This bond issue took place in the middle of several large highway proposals for the Boston area. The total bond issue was close to $3.1 billion, to be supplemented by an additional $1.5 billion in federal funds. The highway projects included $3.2 billion (that later escalated to $4.3 billion) for the reconstruction of a major thoroughfare underground and the construction of a tunnel under the harbor.
regulations). The more detailed calculation of capital and operating costs required by the federal process would not be completed until December of 1987 (later revised in July 1988).

The reason for a 50% share was based on UMTA suggestion that with this share (instead of the statutory 20%) the project will have a better chance of getting federal support (and would probably involve less hurdles). A change in the head of UMTA in November 1987, challenged the federal support for the project, and eliminated the guarantee of the $195 million federal share. The impasse lasted four months, until March 1988, when new talks between UMTA and the MBTA officials put the possibilities of a 50% federal share back in place. The explanation given by MBTA officials was that there existed a misunderstanding between UMTA and the MBTA as to which type of project they were dealing with: 'new start' or 'rail modernization.'

Almost two years after the MBTA had taken all the precautions to persuade interested parties to stay within the limits imposed by the existing rail network, UMTA raised the issue again, slowing the progression of the project.

The technical analysis included, in addition to the commuter rail alternatives, three other alternatives: a no-build, a TSM, and, by recommendation of MDPW, a busway alternative. The state process required the study of the largest and most complicated alternative for its Environmental Impact Report. UMTA, however, also required the analysis of sub-options of the possible total system with enough differences to be able to compare the worthiness of the full system. In the case of the Old Colony project, the sub-options consisted of reconstructing: (a) the innermost line alone (the Middleborough line), (b) this line with the
middle line alone (the Middlegorough and the Plymouth line), and (c) the innermost line and the shore line (the Middleborough and the Greenbush line). For the correct operation of each of the seven alternatives, two or more modes of transportation were included, such as improvements in the existing bus system and rapid transit Red line, or additional feeder bus lines and commuter boat service.

The different components of the study, from demand estimation, to the calculation of capital and operating costs, and to the assessment of environmental impacts, were assigned to different consultant firms in the Boston area. The costing model for both capital and operating costs was based on the principles of buildup costing, in accordance with UTMA guidelines (see chapter 4 for a more detailed description of costing approaches). Table 3.1 shows the cost figures generated in December 1987. Capital costs included a lower and an upper bound, and a best estimate (the middle value shown in the tables) which tried to reflect the uncertainty of some cost figures. However, the values were calculated based on differences in assumptions about particular items. For instance, the busway variations responded to assumptions about lighting on the busway (the lower bound assumed no lighting; the best estimate, lighting every 200 feet; and the upper bound, lighting every 100 feet) or about the trackwork in the commuter rail alternatives (the lower bound assumed only replacement of existing defective ties; the best estimate, all new wood ties with resilient fastenings; and the upper bound, concrete ties with resilient fastenings). These limited assumptions yielded lower values less than 6% lower than the best estimate and upper values less than 0.6% higher than
the best estimate\textsuperscript{66}.

\begin{table}[h]
\centering
\begin{tabular}{lcc}
\hline
Alternative & Annual operat. & Capital costs \\
& maintain. costs (middle values) & \\
\hline
No build & $12,926,801$ & $0$ \\
TSM & $18,308,663$ & $31,949,640$ \\
Busway & $18,408,629$ & $102,580,669$ \\
Commuter rail & & \\
Middleborough & $22,633,791$ & $189,979,064$ \\
Midd./Plymouth & $26,492,298$ & $282,415,561$ \\
Midd./Greenbush & $25,108,638$ & $262,353,966$ \\
Midd./Ply./Green. & $28,957,473$ & $360,975,566$ \\
\hline
\end{tabular}
\caption{1987 Capital and Operating Costs for the Boston Alternatives (November 1987, 1986 dollars)}
\end{table}

Eight months later, after the confidence of UMTA had been regained, new figures were generated. These figures are shown on table 3.2.

\begin{table}[h]
\centering
\begin{tabular}{lcc}
\hline
Alternative & Annual operat. & Capital costs \\
& maintain. costs (middle values) & \\
\hline
No build & $10,955,680$ & $0$ \\
TSM & $14,675,718$ & $30,333,670$ \\
Commuter rail & & \\
Middleborough & $19,001,648$ & $188,363,092$ \\
Midd./Plymouth & $22,860,187$ & $280,799,589$ \\
Midd./Greenbush & $23,137,797$ & $261,107,782$ \\
Midd./Ply./Green. & $26,986,654$ & $359,729,382$ \\
\hline
\end{tabular}
\caption{1988 Capital and Operating Costs for the Boston Alternatives (July 1988, 1986 dollars)}
\end{table}

\textsuperscript{66} For one of the rail alternatives, the upper value was less than 0.1\% higher than the best estimate. When I indicated this apparent discrepancy to the analysts, they stated that it was probably due to a technical error. Were it an error, it had been carried forward through the whole length of the project since the same figures appeared in all the reports from the beginning of the study up to the one that came out in July 1988.
The busway alternative was rejected on the basis of two major considerations. First, operational considerations, since the lower capacity of buses would require an almost constant stream of buses to run during peak hours, interfering with local traffic at grade intersections. In addition, the width of the busway would be too narrow to permit overpassing in the case of breakdowns, and would eliminate the present freight operations. Second, institutional considerations, since a busway would be incompatible with the objective of modernizing the regional rail network, isolating the Old Colony area from the remainder of the MBTA's extensive rail network. Other changes in the cost figures were due to the elimination of improvements in commuter boat service as part of the alternatives since those improvements affected all the alternatives in a similar way.

The Boston case is still on-going. State and local officials kept working at all fronts to secure the approval of federal funds for the full project. Conversations with these officials indicate that they are mostly interested in getting the project ahead. These officials stress the need for the project and praise its advantages but are not aware of the technical results (at most they are familiar with overall figures). They further state that, nevertheless, the study is necessary to validate their pre-defined preferences and comply with federal regulations.

Comments on the Boston Case

The Boston case, as the rehabilitation or extension of an existing system, highlights some particular characteristics of the process. When dealing with extension of existing (well-established) transit systems, the constraints on the technologies to be considered are stronger than in other
cases. In Boston, alternatives different from the commuter-rail ones never attracted major interest from decision-makers. This indifference was reflected in the alternatives under study and can be attributed mainly to the fact that facilities such as maintenance shops and terminals were already in place to accommodate any additions to the commuter rail network. Furthermore, labor groups in the transit agency would probably have complained if a novel technology had been introduced.

Notwithstanding, the study process could be assessed as more straightforward than in instances of new systems since information could be gathered from other parts of the existing system. On the other hand, due to new federal requirements, the scope of the analytical study had to be carried out to a more detailed level than in other instances, making the whole technical process a difficult endeavor. Since demand was to a great extent already known from existing commuter rail lines, cost estimation became one of the most important and time-consuming elements of the planning process.

Shifts in the federal stance towards the project further affected the development of the technical process. First, the definition of the project -- as a 'rail modernization' project -- limited the range of alternatives to be analyzed. Second, increases in capital costs made UMTA suggest that the statutory 80% federal share would not be easily attainable for the Old Colony project. Both factors added to the uncertainty of which level of funds could be obtained from the federal government and put the MBTA in the position of trying to keep costs as low as possible (and perhaps be as optimistic as possible in estimating ridership).

The decision-makers' need to attend to two different audiences further
affected the technical process. The major difference between the two audiences was in emphasis: the state process was concerned primarily with assessing (and addressing) the full range of environmental impacts and insisted that alternatives (or components of alternatives) be examined whenever they meet objectives with less serious environmental consequences; the federal process focused on cost and financing issues and insisted on examination of alternatives which may meet the basic objectives at less (financial) cost. Therefore, the former process allowed cost increases to meet environmental concerns, while the latter tried to encourage limits on capital and operating costs. The clash over the criteria upon which to evaluate the projects is also reflected in the differences between what the CAC as representation of community interests deemed the appropriate evaluating categories and, again, UMTA's emphasis on cost measures.

The Old Colony study stressed the lack of transportation capacity to serve downtown Boston from the Old Colony area (in terms not only of highway capacity but also of downtown parking spaces) in the light of urban developments taking place in the corridor (including the reconstruction of a major highway -- the Central Artery -- underground). These concerns, even if not explicitly indicated in the technical report, broaden the constituency affected by the project. On the other hand, the perception of the goals was not always the same across different groups such as some communities at the local level (e.g., Quincy, Braintree, Weymouth), and may not perfectly fit the interests of the federal government (which at the moment was trying to phase out the provision of funds for transit projects).

The extent of the project, a rail network of 80 miles of double and
single track, increased the number of concerns to be addressed. Station locations and parking lots, for instance, were a constant source of complaints from the affected communities. As a matter of fact, in November 1988 when the DEIS was almost completed, the location of some stations (e.g., South Weymouth on the Plymouth line) was still undecided. This added to the uncertainty of cost elements and of operating strategies because of constraints generated by the predominantly single-track sections of the system (particularly in the segment closer to the CBD terminal). Nonetheless, supporters of the restoration, probably aware of the effects that community concerns might have on the technical process, indicated that although transportation decision makers (including the governor) could have a difficult task persuading local residents about the advantages of the project, they should also make certain that they do not scale down the plans to meet local concerns.

As to the technical process itself, the slight variations between the lower or upper values and the best estimates indicate that no attempt was made to try to reflect the uncertainty of cost estimates. The many other documents that had to be generated in order to comply with state and federal requirements (ten volumes, two of which referred specifically to

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67 In November 1988, a nonbinding referendum held in Quincy and Braintree (the two communities closest to Boston’s CBD where the commuter service was going to pass by but did not have any stations) asked people how they think their state representatives should vote in the Legislature in relation to the restoration of the Old Colony lines. Analysts and decision makers were glad to know that the referendum gave some support to the restoration of the line (around 60% in favor and 40% against). However, they did not like the results of another vote, this time in Braintree only, about the possibility of making the Braintree station a transfer station. This vote resulted in an almost 50/50 decision, what did not help clarify the community support on this issue.
capital and operating costs) and how cost information was organized (mainly in computer-based spreadsheet) did not encourage a full sensitivity analysis.

Rather than costs, two other major (and time-consuming) concerns absorbed analysts and decision makers. The first one was the relation with the communities in the corridor so that they could know exactly how the project would affect them and voice their concerns. These meetings were also a good opportunity for the MBTA to gain support for their proposals. The second major concern involved the cost-effectiveness criterion required by UMTA's regulations (this process is explained at greater length in chapter 4). This criterion had not been publicized by the time capital and operating costs were calculated (and by the time this thesis was written) but the quietness of the analysts when asked about the criterion leads to the presumption that the project did not fare very well on that criterion. This apparent shortcoming of the project probably forced decision makers to increase negotiations with the federal government to reduce the possibility of rejecting the project on the basis of that criterion, trying to relegate the cost-effectiveness evaluation to a second stage.

The Boston project has not been constructed yet. Its history,

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68 Between 1985 and 1988, the project manager (MBTA official) held around 200 meetings with the communities affected by the project. In some times, meetings were held three or four times in the three year period. (Conversation with MBTA officials, July 1988.)

69 In several conversations with key people involved in the project, no answer was given when asked about the value of the cost-effectiveness measure, or the question was avoided altogether.

70 Section 5.3 discusses this issue at greater length.
however, indicates many of the issues involved in the cost estimation process and mainly the pressures exerted by different parties and institutions over the technical process in an attempt to reflect their ideas about the purpose and worthiness of the transit project. The next two cases, Santa Clara County's LRT and Buffalo's LRRT, illustrate some similar issues and some other issues from the perspective of two fixed-guideway systems that were constructed in cities with no previous rail systems in place. In addition, both systems have recently been opened (only the first section for the Santa Clara's LRT, though) and, therefore, give a perspective from a completed system. In these cases, however, it was harder to gather information on the preliminary stages of the planning process and the individuals interviewed tried to emphasize more the performance of the operation of the existing system at the present moment rather than the difficulties in the planning stage.

3.2.2. Santa Clara County's LRT

Introduction

The case of Santa Clara County illustrates the situation in a fast growing area with conditions unfavorable to fixed-guideway transit systems (e.g., low density developments or high income population) but plagued with traffic congestion which ultimately could thwart the pace of growth and development in the area. This fear created the belief that it was necessary to avoid the experiences of other cities in the same part of the country (mainly, Los Angeles) and try to redirect the land use patterns in the area. The presence of strong advocates for a fixed-guideway system (basically, an light rail option) at the decision-making level very much
determined the survival of the project until its implementation in spite of the many set-backs that took place throughout the process.

Unlike the Boston case, Santa Clara County is predominantly a suburban area, with low density, and a transit system -- 470-bus fleet operating on 79 routes and limited commuter rail service on the peninsula to San Francisco -- that has only lately received some consideration. The county houses the forefront of the world's high-tech industry (known as the Silicon Valley), and includes the cities of San Jose and Santa Clara. The growth of the electronics industry for the past fifteen years has been accompanied by a similar growth in the population and residential development in the county. This growth has led to high levels of congestion, aggravated by the suburban character of the area.

In 1975, the county's employment base of 502,000 jobs was growing at a higher percentage rate than its population of 1.1 million persons and its resident labor force of 490,000 workers. Countywide, more than four million person trips were being generated daily, only one percent of which were on public transit. The region known as the Guadalupe Corridor -- for it goes parallel to the Guadalupe River -- encompasses a portion of the county with an area approximately 16 miles long and 5 miles wide. In the 15 years from 1975 to 1990, the corridor area was expected to grow from 360,000 to 420,000 in population and from 187,000 (.519 jobs per person) to 383,000 (.912 jobs per person) in the number of jobs. This growth was to generate 50% more trips than the 1.2 million trips generated in the corridor in 1975. 71

71 United States Department of Transportation, Urban Mass Transportation Administration [1981], page 2-1.
The locational imbalance of jobs and housing and, consequently, the predominant southeast-to-northwest travel pattern (from South San Jose to North San Jose and Palo Alto) created delays on the major roads during peak hours. Congestion was exacerbated by the continual development of the semiconductor industry in the mid-1970s. In addition, state freeway projects slated for construction by 1970 had not been completed -- though the right-of-way had been purchased --, aggravating congestion on major highways and arterials, with traffic spilling over onto local streets, causing increasing intrusion into and disruption of residential neighborhoods. By the end of the 1970s, with growing congestion and climbing gasoline prices, ridership in the bus system almost doubled between 1978 and 1981.\(^{72}\)

Concerns, however, were broader than the mere traffic congestion. A 1976 report, the "Santa Clara County Transit District Light Rail Feasibility and Alternatives Analysis," quoted the then UMTA Administrator, Robert Patricelli, stating that "[r]apid transit is part of becoming and being a great city." The study concluded that

"Santa Clara County is essentially facing the choice of a future similar to that which exists today in Los Angeles ... or one which provides the option for some of its urban area -- by no means all -- to accommodate itself to transportation and urban development characteristics associated with one or more rail lines. (…) In the final analysis, however, the choice is dependent not on technical information alone, but on the unique and special way the County perceives itself and the future toward which it wishes to move."\(^{73}\)

Other concerns included the perception that residential growth could only occur if the additional transportation capacity were provided. The

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\(^{72}\) Ibid., page 2-3.

\(^{73}\) De Leuw, Cather and Company [1976], p. 326.
City of San Jose's plans for some additional 50,000 new dwelling units by 1990 in the south of the city could only be carried out if new transportation facilities were constructed. Furthermore, a rail-based transit system would help encourage growth in the downtown area where revitalization was very much needed. Overall, these concerns amounted to an attempt not to constrain further growth in the area. If transportation improvements were not made, the region would not be able to support the inevitable growth.

Other concerned parties stressed the role of transit projects in developing a diversified transportation system that would prevent any problems in case of oil shortages, and at the same time would meet the travel needs of different segments of the population and of different urban communities. But at the forefront of the desires for a major transportation improvement, public officials underscored the attempt to guide land use development and encourage denser development patterns in the process of directing the inevitably expected growth. At some point the proponents of the system said that the preferred transportation system (mainly a light rail line and improvements in highways) could make Silicon Valley the "Paris of the West Coast." "It will determine more than any other action whether we will be a great community in the 21st century in that it establishes the mode of interurban transportation for the next 100 years."

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74 Santa Clara County Transit District [1981], page 20.

75 This goal was supported on the grounds of a strong belief that land use and transportation decisions influence one another.
years" 76. Later, they also indicated that the "[federal] administration realizes that the Guadalupe Corridor project not only is a relatively low cost project, but that it offers a unique opportunity to directly benefit the growing defense, aerospace and electronics industries which are some of the few bright spots in the U.S. economy" 77.

All these concerns fed the perception of the need to develop transportation facilities in the Guadalupe Corridor. Development of the transportation system have lagged sharply behind private residential and employment development, and some studies had to be undertaken to provide the evaluation necessary to give local decision makers the required information for choosing the adequate transportation mode to address the travel needs of the corridor.

In the mid-1970s the studies began to define the problem and identify solutions. The studies have now been translated into a 20-mile LRT system linking residential communities in the south of Santa Clara County with employment concentrations in the north, including the famed Silicon Valley 78. The system also sought to return the centrality of downtown San Jose with the provision of a 10-block-long mall located approximately at the midpoint of the line. At the same time, a four-lane freeway will also be built paralleling the line south of downtown. (Figure 3.2)

Institutional Environment

The Santa Clara County Transportation District (SCCTD), the agency

76 Statement by County Supervisor Rod Diridon, San Jose Mercury "Major transit decision is near," October 14, 1981, pages 1B and 2B.

77 Santa Clara County Transit District [1981], page 26.

78 Actually, only the north portion, with a length of about 10 miles, was opened by the end of 1988.
that led the project throughout the planning process, acts as the transportation authority in Santa Clara County with the responsibility for the planning and operation of transit services in the county. The cities of San Jose and Santa Clara, which the corridor of analysis traverses, are responsible for supervising transportation infrastructure investments within their boundaries. The scope of the project, affecting two municipalities, required the involvement of several other coordinating agencies. Among these, the Association of Bay Area Governments (ABAG) has the responsibility for coordinating planning development efforts in the San Francisco Bay area and makes predictions about population and employment changes in such area. The Metropolitan Transportation Commission (MTC) oversees performance audits 79, and helps allocate state monies and coordinate transit services, fares, and operations among the different transit agencies operating in the area. At the state level, the California Department of Transportation (Caltrans) also had a stake in the process as soon as the SCCTD sought funds from the state government. The support of Caltrans was also necessary for requesting funds from the federal government.

All those institutions coalesced into a decision-making body labelled 'Board of Control.' The Board of Control for the Guadalupe Corridor transportation project included elected and appointed officials from Santa Clara County Transit District, City of San Jose, City of Santa Clara, Association of Bay Area Governments, Metropolitan Transportation Commission, and Caltrans. The Board of Control provided policy direction

79 State legislation requires operators and transportation planning agencies performance evaluations every three years.
Figure 3.2
Santa Clara County LRT

Guadalupe Corridor LRT Project

Legend:
- Light Rail Transit Route
- Maintenance Facility
- Transfer Mall
- Station with Park & Ride Lot
- Station
- Proposed Regional Transit Terminal
in the process of analyzing alternatives, coordinating with local
government bodies affected by the project, and helping administer the
overall planning analysis.

In addition, to effectively coordinate the views of all government
agencies involved in the Guadalupe Corridor study and to assist the Board
of Control, a technical advisory committee was established at an early
stage in the process, in 1979. This committee, composed of representatives
from UMTA, Federal Highway Administration, Caltrans, the Metropolitan
Transportation Commission, Cities of San Jose and Santa Clara, and the
SCCTD \textsuperscript{80}, met on a monthly basis and reviewed the technical data submitted
by the consultants and participating agencies.

Probably one of the most significant differences in California's
transit environment compared to the other case studies is the financial and
institutional support provided by the state legislature. The institutional
climate is often not very receptive to transit investments. Although
several measures had been put in place to ensure a relatively stable base
of support for all local transit systems, the number of projects
implemented have been few and far between and supported by a very small
number of legislators. The achievements are mainly a reflection of the
vigorous advocacy played by key legislators. Transit must compete for
funds with other state programs, and most of transit funds, unlike state's
highway funds, are not constitutionally dedicated \textsuperscript{81}. This situation

\textsuperscript{80} Almost half of the members of this technical advisory committee
belonged to SCCTD.

\textsuperscript{81} There exists, however, a 1/4 percent general sales tax dedicated to
local mass transit, and a formula-based share of gasoline tax
revenues. In fiscal year 1983-84, the state provided approximately
$715 million in transit funds.
has created a piecemeal process whereby legislative involvement has come in increments rather than through a prolonged, comprehensive action. Interestingly enough, the legislature has established some performance and productivity measures to assure that transit funds are spent in an efficient manner. For instance, local support in the form of local matching funds, minimum farebox revenues, or contributions from property taxes and bridge tolls, is required. These local efforts are necessary as a proof of local interest and commitment, and to limit the state’s costs.

Project History

The history of the Santa Clara County (Guadalupe Corridor) Light Rail System spans over a period of more than 15 years. The initial proposals for specific transportation solutions date back to 1974 when consultants to Santa Clara County began a study of the county’s transportation needs with the year 2000 as the horizon year. This preliminary study recommended a medium-capacity transit guideway network -- consisting of 140-miles of track -- fed by an extensive bus collection system.

The County Transit District contracted another study in December 1975 to investigate the feasibility of light rail or bus transit alternative in five of the highest demand corridors identified in the first study. In this study, the Guadalupe Corridor was singled out as the most feasible route with the greatest potential for high ridership. This study, published in August 1976, indicated that "[n]one of the alternatives studied except for the baseline bus satisfied the given constraints on capital and operating costs." (Incidentally, the study assumed an 80

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82 This was the "Rapid Transit Development Project".
83 DeLew, Cather and Company [1976].
percent Federal matching grant.) Nonetheless, a light rail system would be the only mode that would be capable of attracting 15 percent of the 1990 peak-hour travel -- the goal of the City of San Jose's General Plan '80. A starter line would cost $113 million in 1976 dollars for a total length of 12.5 miles.

The study concluded with some actions to seek early UMTA approval and what actions to pursue to achieve this approval. Taking into account the then recent rejection of the Denver Region's request for an LRT starter line after completing studies worth millions of dollars, and the approval of the Buffalo's LRT line based on "population density, size of the downtown CBD employment, ease of automobile access, expected number of daily riders in the short-range, and the total annualized costs per passenger carried (cost-effectiveness)" 84, the study recommended that the UMTA waters be tested to avoid "the wasting of scarce funds on pointless additional studies and/or could help focus the County's efforts most productively." 85

In 1975, the "Santa Clara Valley Corridor Evaluation" (SCVCE) was started, including an assessment of future transportation needs. This study constituted the first phase of the federal-required 'Alternatives Analysis' process and, by its completion, had included over two hundred public meetings and workshops to solicit comments 86. The study concluded that transit could carry up to 12% of the work trips during peak travel

84 Ibid., page 352.
85 Ibid., page 353.
86 Joint Policy Committee of the Association of Bay Area Governments and Metropolitan Transportation Commission [1979], page 2.
periods, and that none of the transit options would recover more than 31% from the farebox. The study also indicated that current transit funding would allow for an approximately 700-bus system plus about 10 miles of rail transit on the Southern section of the city of San Jose and an upgrade of the commuter rail system (the Southern Pacific line).

Even before the completion of the draft report, the consultants' preliminary recommendations advocated the construction of light rail transit (LRT) as the mode to link downtown San Jose with the southern residential areas. The predilections for an LRT system were attuned with the preferences (for a rail system) strongly voiced, from the beginning of the proposals, by some local elected officials. In 1976, the Board of Supervisors of the Santa Clara County Transit District (SCCTD) was vested with decision-making powers regarding transit proposals. In addition, voters approved a half-cent sales tax to finance the SCCTD.

The SCVCE considered nine transportation alternatives and several land use scenarios for Santa Clara county in 1990. The report stated that the Guadalupe Corridor had long been master-planned for major freeways (state Routes 87 and 85) which had never been built and that the right-of-way was then over 70% in public ownership. For these reasons, in the SCVCE Draft Report that came to light in 1978, the consultants concluded that alternatives along the Guadalupe Corridor deserved the largest consideration. The reserved right-of-way was a good advantage for a fixed guideway system, and particularly for their recommended 10-mile light rail starter line between San Jose and the southern areas. They further recommended the acquisition of the remaining of the right-of-way property and the construction of a four-lane freeway -- between I-280 and Curtner
Avenue -- within that right-of-way.

Regional and local governments approved the conclusions but indicated that areas north of San Jose should also be included in the rail-line plans. Subsequent to the completion of the SCVCE, in 1979, UMTA approved plans totaling $650,000 to conduct the Alternatives Analysis process to evaluate transportation alternatives in the entire corridor and the production of an environmental impact statement 87. In August 1981 the Alternatives Analysis/Draft Environmental Impact Statement (DEIS) was published and circulated for comments. UMTA indicated that at the moment federal policy (Reagan had started his first presidential term 8 months earlier) was to defer any new rail start, so Santa Clara County should not expect Federal involvement in the project 88.

The Alternatives Analysis report stressed the importance of the area (the Silicon Valley) to the rest of the nation. The report stated that the fact that the county was the center for the U.S. electronics industry could not be overlooked. It also indicated that competition from other countries in the world could be counteracted by providing the necessary transportation capacity to the county, which would allow an increase in the number of housing units at affordable prices.

The draft environmental impact statement (DEIS) documented the environmental impacts of 14 alternatives for transportation improvements in the Guadalupe corridor. It also documented the anticipated costs, impacts


88 As indicated in the Boston case, UMTA policy at that moment was to defer federal involvement in new rail starts and extensions until economic conditions improved, except where Interstate Transfer Funds are available to fund these projects.
and benefits of those alternatives in order to facilitate informed decision-making regarding implementation of a transportation facility within the Guadalupe Corridor. The statement had been prepared in accordance with both the provisions of the Council on Environmental Quality in California and U.S. Department of Transportation/UMTA regulations.

The alternatives included: (a) no-build, (b) baseline TSM (including some highway construction), (c) busway/high occupancy vehicle (HOV) lanes, (d) only-LRT (including TSM improvements), (e) busway/freeway, (f) busway/expressway, (g) LRT/expressway, and (h) four alternatives related to the expansion of the commuter rail service. Alternatives (b), (c), and (d) had parallel alternatives with no highway construction. Alternatives (b) to (g) also included a bicycle facility throughout the full length of the corridor. The fourteen alternatives were quickly reduced to three as discussions focused on alternatives (c), (d), and the locally-preferred (g).

The light rail options consisted of 20 miles of new double-track line (figure 3.2). LRT operation would require 50 vehicles, and daily mileage would amount to 9,091 miles. Table 3.3 shows the estimated capital and operating costs for the three most controversial alternatives as well as the daily patronage forecasted for all transit modes -- express buses, light rail, and commuter rail -- in the corridor.

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89 The inclusion of highway alternatives led to the appearance of the Federal Highway Administration in the process as the overseer of the highway options. The busway/HOV alternative was included at a later stage at UMTA’s request.

90 Although the bikeway was a merely $1 million investment, it was given as much space in the brochures advertising the project as the LRT and expressway investments which amounted to more than $275 million in 1980 dollars (1981 estimates).
Table 3.3
Capital and Operating Costs and Daily Patronage for Selected Santa Clara County Alternatives
(Cost figures in 1980 dollars)

<table>
<thead>
<tr>
<th>Alternative</th>
<th>1990 operat. &amp; maintenance costs</th>
<th>Capital costs ($) thousands</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily patronage (all transit)</td>
<td>($ thousands)</td>
</tr>
<tr>
<td>Busway/HOV lanes</td>
<td>41,800</td>
<td>$96,400</td>
</tr>
<tr>
<td>LRT only</td>
<td>44,800</td>
<td>$93,500</td>
</tr>
<tr>
<td>LRT/Expressway</td>
<td>43,600</td>
<td>$93,400</td>
</tr>
</tbody>
</table>


In order to achieve a consensus, the board of control adopted a public participation strategy in an attempt to: (a) encourage expression of a wide variety of opinions; (b) allow maximum dialogue between technical staff, consultants and the general public; and (c) permit maximum opportunity for public review of technical materials. The strategy proved successful in supporting the board’s preferences and in November 1981, SCCTD and the cities of San Jose and Santa Clara selected Alternative 6, the light-rail/expressway/bikeway alternative, as the locally preferred alternative.

Over 300 meetings and workshops were held with community leaders and community organizations. Some of the concerns voiced in these meetings, reflecting a wide diversity of opinions, included: (a) how much each alternative would cost the taxpayers; (b) that ridership figures were too low (vocalized by the light rail advocates) or too high; (c) the disclosure of public opinion polls; (d) that the decision about the light rail line had already been made and that the study was a way to justify it; (e) that the board of control was biased in favor of the LRT; (f) that highway projects should be completed; and (g) that contingency plans should be developed in case funding from state and federal sources did not materialized.
92. SCCTD promptly applied for Section 3 federal funds to proceed with the preliminary engineering of the light rail line. The Santa Clara County Transportation Commission endorsed by a majority vote (15-6) the technical recommendation and urged the approval by the Guadalupe Corridor Transportation Board of Control. On October 28, 1981, the Board approved the Technical Advisory Committee's recommendation by majority vote (six in favor, one against, and one absent).

Upon sending the report of the locally-preferred alternative, the chairman of the SCCTD board of Supervisors stated that the decision was a land use decision and a "quality of life" decision. Other reasons for the support included: (a) if by 1990, there was a justification for expansion of the transit system, LRT would be less expensive to expand; (b) if there is a sudden crisis -- such as oil shortages or strikes -- which required additional transit capacity, LRT would be less vulnerable and would offer the best opportunity for tackling the problem 93. A local newspaper stated that "[s]ome form of a light-transit system would be safer, less polluting, faster and cheaper than any other solution including another highway or a

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92 Measure A, a non-binding, advisory vote of confidence on the County Transit District's nearly $1 billion transportation-improvement plan for the 1981-86 period (that included the design and construction of a fixed-guideway system, either light rail or a busway), was approved with 85% of the vote. This vote suggested that the public was enthused about mass transit.

93 Some parties, particularly from LRT-interest groups such as the Modern Transit Society, even claimed that the LRT system could carry 50,000 passengers per hour. Vuchic [1981], based on an analysis of several systems all over the world, estimates that capacities of LRT systems fall between 15,000 and 20,000 persons per hour (page 577).
special roadway for exclusive use by buses and carpools" 94. Farebox revenues were expected to cover 85% of operating and maintenance costs, compared to 57% for buses. The 1981 report on the preferred-alternative report further stated that although expressway alternatives would have a reasonable chance of being funded, there would not be sufficient local, state, and federal funds available to fund the large capital costs of the highway portion of a freeway/busway alternative 95.

At that moment, the California Department of Transportation (Caltrans) supported the LRT-only alternative, and threatened not to provide the almost $1 million of state money needed for the corridor study for the LRT/Expressway alternative 96. Caltrans staff was not convinced that light rail patronage would be about the same with or without the competing highway link. These events were denounced by the San Jose City council as an usurpation of the authority of local decision-makers. Eventually, other state agencies -- the Business, Transportation and Housing Agency, and the California Transportation Commission -- persuaded Caltrans to reverse their earlier position and deliver the study money. Still, among the general public, the proponents had their share of critics. Some people wanted a


95 Santa Clara County Transit District [1981], page 20.

96 The State Transportation Director was then depicted by her anti-highway convictions (San Jose Mercury, "More studies, no transit," June 25, 1980 page 14B). In February 18, 1980, The Mercury News indicated that "[w]e are sick and tired as anyone of paper exercises, but this study ... is a necessary step if the area is going to be eligible for federal mass transit money." In December 7, 1980, The Sunday Mercury News, "[p]ublic planning agencies have an extraordinary ability to deal in esoteric terms which mean nothing to most of us, and nowhere is this more true than in our planning for public transit."
busway facility that could be upgraded to LRT when patronage warranted it; others expressed concern that funding for the LRT could be cut off by the federal government at any time; others indicated that a busway/HOV would maximize independence from bureaucracy and annual labor disputes because it would easily permit privatization.

In March 1982, UMTA responded to the preferred-alternative report and the SCCTD request with a technical assessment of the alternative transportation investments. In this report, UMTA indicated that land use patterns in Santa Clara County do not support a rail alternative mainly because ridership, a major consideration for a successful implementation of a light rail system, would probably be limited by "difficulties in access to the system and the lower than average potential for direct service" (i.e., passengers would need to take a bus to a station, then ride the LRT, and then again take another bus from the LRT station closest to the end-trip destination). UMTA further indicated that the four basic arguments in support of light rail did not have a strong footing. For instance, the busway/HOV facility was put at a disadvantage by not considering the flexibility of this facility as a means of accommodating increased demand.

An individual, member of a homeowners association, explained why she advocated the denial of federal funding for the LRT project in the following terms: a) net costs of light rail and busway/HOV appear to be virtually the same because although a busway/HOV transit system would cost approximately $9,300,000 more per year to maintain and operate than a light rail system, this latter system would cost approximately $93,000,000 (or approximately 70%) more than a busway/HOV lane transit system; b) therefore, investing the extra $93,000,000 capital at 10% per year would pay for this difference (alternatively, one could also state, if the money were borrowed, $9,300,000 per year debt service would have to be added to the LRT operating and maintenance costs); and c) since overall a busway/HOV transit system would get people to work faster, the LRT alternative was not the optimal one on a cost-effective basis. (Letter to the UMTA regional administrator, February 17, 1981.)
for transit. In addition, UMTA indicated that although light rail would reduce subsidy requirements by about 5%, capital costs make light rail the least feasible alternative. Furthermore, the interpretation of the economic efficiency data could lead to the inference that either the busway option was 43% more cost-effective in shifting auto users into transit and HOVs, or that the investment required for the light rail proposal beyond that required for the busway actually decreased the economic benefits.

The report concluded that the busway/HOV would be more consistent with local land use patterns because it would remove the need for many transfer trips. In terms of cost per added transit/HOV user, the busway alternative would be more cost-effective than the light-rail alternative. By January 1983, an impasse had been created, and the UMTA Federal Administrator indicated the resistance of the county in looking at buses and carpools as an alternative. Later that year, in March, SCCTD agreed to expand the analysis of the busway option. This more detailed analysis was finished in April. In June, a Santa Clara delegation presented the final EIS to high-level DOT/UMTA staff and requested additional grants to carry out the final design of the selected alternative. Nonetheless, in July 1983, the regional UMTA administrator recommended to SCCTD that the busway/HOV alternative be withdrawn from the FEIS because of concerns about how its

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98 These data indicated that increased transit/HOV use would be gained at costs of $1.66 per new passenger for the busway alternative, and $2.37 for the light rail alternative.

99 He further indicated that "the County's approach will not provide the technical analysis and evaluation that we think should be performed before either the light rail proposal or bus and carpool facilities are advanced into final design and construction."
cost-effectiveness had been calculated in comparison to the rail alternative.

On August 19, 1983, the final EIS was published including public comments on the AA/DEIS and responses to significant environmental issues. Previous to this, the House of Representatives of the U.S. Congress, through its appropriation committee, recommended to UMTA the approval of the construction of the entire 20 mile Guadalupe Corridor light rail project and the issuance of the necessary paperwork for Section 3 discretionary funds.

In September, SCCTD responded to the questions raised about the cost effectiveness of the busway alternative but did not delete this alternative from the FEIS that had already been approved by UMTA and the FHWA. The regional administrator however indicated that no funding contract would be signed until the cost effectiveness issues were resolved. Congressional pressures over UMTA, however, made the federal office encourage the regional office not to delay the approval of the project, mainly because, in spite of everything, the LRT alternative was still a cost-effective and an environmentally preferable alternative. The regional office then proceeded to approve funding for right-of-way acquisition only.

Complaints by opponents of the alternative selected (that is, the LRT/Expressway alternative) -- such as the bias against the busway alternative and the lack of overall consideration of the effects of the LRT proposal -- were abundant at this time. Nevertheless, UMTA and FHWA announced the decision to provide financial assistance for the construction of the Guadalupe Corridor Project as a response to a congressional mandate. UMTA justified the decision by indicating that LRT had the opportunity for
private sector participation, minority business enterprise contracting opportunities, and the higher than required local matching commitment.

The full funding contract between the SCCTD and UMTA was signed on June 22, 1984. The total cost at that moment was estimated at $411,075,000, of which $39,150,000 were for the budget related to the transit mall. Out of the $411 million, 36.67% would be covered by local funds, and 63.33% would be covered by the federal government (subject to availability of funds from the Congress) \(^{100}\). Those amounts were in current values assuming construction would be ended in 1987 and with an inflation (escalation, they call it) rate of 7.5% beginning in March 1984 (for those items already underway no inflationary escalation was anticipated). Any additions, changes, etc. to the system that would increase costs would need to be covered with local funds, except in cases of extraordinary costs -- namely, inflation beyond the expected rate, acts of God, eminent domain cases, costs directly caused by Federal legislation, and those caused by unavailability of funds from Congress.

The SCCTD agreed to secure and provide (without further Federal assistance) whatever additional resources were necessary to pay for extra amounts not covered as extraordinary and complete the project. The full funding contract also included the condition that the SCCTD would not request Federal operating assistance in excess of the smaller amount between the one specified by Section 9 or the one set forth by the SCCTD in

\(^{100}\) The cost for the LRT included 31 stations and 9 park and ride lots. The $39 million for the transit mall were going to be covered 70% by UMTA and 30% with local/county funds. The highway component of the transportation project was a four-lane freeway with an estimated cost of $106 million to be funded 41% by the Federal Highway Administration, 37% by the city of San Jose, and 22% by the County Transit District.
its five year plan of March 22, 1983. Anything in excess of this will be funded from State and local sources. In its appendices, the contract specified which items of the project would be covered by local or federal sources (e.g., 45 articulated light rail vehicles, without including spare parts, tools, training or technical support, was stated as local activity). In another appendix, the contract with the State indicated that no more funds could be requested from State sources than those specified in 1983 ($60 million).

A few weeks after UMTA decided to provide the funds, a group labelled as "People for Efficient Transportation" filed a suit in U.S. District Court for the Northern District of California. This group alleged that there was a lack of adequate consideration of modal alternatives, among them the busway alternative, that they believed were environmentally preferable and more cost effective than the LRT alternative. They requested an injunction against any construction or expenditures for the Guadalupe Corridor transportation facility. The effect of this lawsuit was a delay in the development of the project for almost 24 months. The first 10 miles of the LRT system were opened for revenue operation in May 1988.

Table 3.4 indicates the changes in the estimates of capital and operating costs from the 1976 study to the initial construction of the system. It is interesting to note that the 1976 estimates indicated a cost of $168 m. for a 20-mile LRT, assuming constant returns to scale (i.e., assuming proportionality). Decreasing returns would probably yield values

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\[ \text{(continued on next page)} \]

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\[ \text{(continued from previous page)} \]

\[ \text{In fact some of the vehicles started running on December 31, 1987 to make use of harbor leasing proceedings that helped the SCCTD save $7 million dollars.} \]
very close to the ones estimated before the 1984 full funding contract. In other words, the 1976 estimates seem to have been more accurate than subsequent estimates.

Several reasons can be pinpointed for cost increases since the signing of the full funding contract (table 3.5 provides a summary of them):

(a) locally funded project enhancements: After the full funding contract was signed in 1984, a number of local initiatives were studied to

Table 3.4
Comparison of Capital Cost Estimates for Santa Clara Light Rail

<table>
<thead>
<tr>
<th>Study/Year</th>
<th>Proposed System</th>
<th>Constant 1976 $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santa Clara County Transit District Light Rail</td>
<td>34.08-mile LRT</td>
<td>$268</td>
</tr>
<tr>
<td>Rail Feasibility and Alternatives Analysis</td>
<td>12.25-mile LRT</td>
<td>$113</td>
</tr>
<tr>
<td>(1976)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternatives Analysis/UMTA Grant Application</td>
<td>20-mile LRT</td>
<td>$180</td>
</tr>
<tr>
<td>(1981)</td>
<td></td>
<td>$132</td>
</tr>
<tr>
<td>$137</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guadalupe Corridor</td>
<td>20-mile LRT</td>
<td>$320</td>
</tr>
<tr>
<td>Full Funding Contract (1984)</td>
<td>20-mile LRT</td>
<td>$372</td>
</tr>
<tr>
<td>w/ transit mall</td>
<td>$411</td>
<td></td>
</tr>
<tr>
<td>$219 *</td>
<td>$242 *</td>
<td></td>
</tr>
<tr>
<td>Forecast Update/Cost to Complete Estimate (1988)</td>
<td>20-mile LRT</td>
<td>$559</td>
</tr>
<tr>
<td>w/ transit mall</td>
<td>$305 *</td>
<td></td>
</tr>
</tbody>
</table>

Sources: Santa Clara County Transit District Engineering News Record (building cost index) Own calculations

* These values are an approximation whereby costs have been discounted from the year 1987, as the approximate year of construction (construction started in 1984 and is scheduled to be completed in 1991).
improve the basic LRT system (e.g., transit mall extension, automatic train protection in the South Line, Community Sound Walls, etc.), and other locally-funded projects were mandated by the California Public Utilities Commission (such a grade separation, underpass, at a railroad crossing on North First Street \(^{102}\));

(b) preliminary estimates: At the time of the full funding contract, estimates were based on preliminary design concepts and, as such, swings of 30% were anticipated; some estimates such as the vehicle costs proved very accurate, while other such as professional services were too low;

(c) environmental delays: The law suit concerning grade separation in some 3.8 mile in the South Line, delayed the award of contract to the lowest bidder; a Supplemental Environmental Impact Report (SEIR) which evaluated 10 design alternatives required a lengthy process; also the Transit District decided to delay the Final SEIR until other risks related to asbestos were studied in more detail; these events delayed the beginning of the construction 24 months;

(d) Measure A impacts: this measure involved an increase by 1/2 cent in the sales tax to fund improvements in local routes, and particularly on the expressway in whose median the LRT was going to be located; after this measure was passed, LRT stations and park and ride access had to be upgraded and therefore made more complex and expensive;

(e) utility escrow for private utility relocations: At the time of the full funding contract, it was assumed that private utilities would pay

\(^{102}\) Public officials complained about this requirement since only a few trains per day use this railroad line.
for any relocation of their facilities in the public right-of-way; a utility escrow was set aside, pending the final ruling of the Court;

(f) transit mall: Design services and construction change orders increase the cost of the transit mall by $5 million.

<table>
<thead>
<tr>
<th>Table 3.5</th>
<th>Reasons for Cost Growth in Santa Clara County’s LRT (1984 - 1988)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(growth of $147.5 million = $558.6 m. - $411.1 m.)</td>
</tr>
<tr>
<td>Cost</td>
<td>Percent of total cost increase</td>
</tr>
<tr>
<td>increase</td>
<td>($ millions)</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Locally funded</td>
<td>$32.1 21.8%</td>
</tr>
<tr>
<td>Prelim. estimates</td>
<td>$62.5 42.4%</td>
</tr>
<tr>
<td>Environm. delays</td>
<td>$24.6 16.7%</td>
</tr>
<tr>
<td>Measure A impacts</td>
<td>$8.3 5.6%</td>
</tr>
<tr>
<td>Utility escrow</td>
<td>$15.0 10.2%</td>
</tr>
<tr>
<td>Transit mall</td>
<td>$5.0 3.4%</td>
</tr>
<tr>
<td>Total cost increase</td>
<td>$147.5 100.0%</td>
</tr>
</tbody>
</table>

Note: Unexpected inflation effects are embedded in those items that caused delays in the construction of the project (mainly environmental delays) or in those that presented unanticipated cost increases.

Initially the LRT line was going to be located in the median strip of a highway designed for expressway standards (that is, with signalized intersections and not fully separated). Later, as response to voters' demands, when County Measure A was passed in 1984, the highway was upgraded to freeway standards, requiring full separation. The new stations on the line then were redesigned according to these standards. In addition, the LRT track had to follow the same profile as the freeway.

Paradoxically enough, the redesign of the expressway to freeway standards, along with the required LRT changes, was perceived by some as a major drawback for the LRT line. In an area were most people drive cars, a
freeway along an LRT would not be likely to take people out of the cars. Furthermore, the redesign forced the construction of overpasses that LRT patrons would have to climb up and down to get to the stations. The effect of this inconvenience would be that, once near the highway, people would rather stay on it and finish the whole trip on their cars. At the other side of the line, the northern portion, another deterrent to transit use consists of the distance -- almost a quarter of a mile -- an individual must walk, across some landscaping strip and a parking lot, to get to a building from a LRT stop. The way buildings are normally designed, because of city requirements, is such that generous landscaping strips are provided in between the street and parking lots. There is also almost a guaranteed, free parking space for every employee. All these conditions amount to strong disincentives to abandon the private automobiles and take the LRT line. Ridership figures for the year 2000 have been put down to around 6,000 from initial estimates of 20,000 to 40,000. The main reasons consultants revised the demand estimates were voter's demands for the freeway standards parallelling the rail line, and because trains will traverse downtown San Jose at 10 to 15 miles per hour.

Administrative costs, for the final figures, were around 30% of the total costs, well above the usual 10%. SCCTD officials were not sure why that was the case, but a possible explanation was related to the many times

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103 For the first half of the system, daily ridership was 3,000 for the first three months of operation, although this is not a definite figure since transit systems require some time for people to get used to them.

104 An express bypass was considered at some point at the end of 1986 but did not prosper, mainly because downtown merchants and businessmen did not like the idea.
the system had to be redesigned because of citizen opposition or law suits, and hence consultant fees and other administrative tasks increased substantially. Any enhancements to the system had to be paid out of local funds since under UMTA's mandate and the full funding contract, the original scope and budget had to be kept intact. The full funding contract was signed by UMTA after the corresponding appropriation was made by the U.S. Congress. Therefore, at the end, funds were earmarked and mandated by the U.S. Congress, not actually approved by UMTA as a result of the process of analysis of alternatives.

Local public officials underscored the inappropriateness of the federal planning process and the annoyance that it causes in the local decision-making process as it cannot address the needs and particularities of different local constituencies. The technical studies are necessary, they stated, but there are other issues that can easily override any conclusions from those studies. This apparent disdain at the local level for the technical components of the project produced tensions with the federal regional office and delayed the initiation of the project and prevented its approval through the formal federal procedures.

Comments on the Santa Clara Case

Public opinion indicated that highways were largely supported as the way to improve the transportation conditions in a wealthy and predominantly service-oriented area. Some political compromise was reached between

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105 A consultant firm was contracted to undertake the project management oversight (PMO) to avoid mismanagement of project funds and complete the project with the specified cap on Federal funding participation. The PMO firm had also the role of providing UMTA with a reliable and independent source of objective information relative to all aspects of the engineering, design, procurement, and construction of the LRT system. The services of the PMO firm were engaged by UMTA.
freeway and transit advocates, to include alternatives that comprised LRT, expressways, and improvements in the bus system. At some point, the chairman of the Board of Control explicitly indicated that freeways had to be built to placate those who consider highways the most efficient transportation system conceivable. The pooling of several modes reduced the chances of opposition from some parties and increased the likelihood of constructing the LRT system.

However, the consideration of expressways and LRT on the same corridor created some contradictions, since the former would detract riders from the latter, reducing its effectiveness. The hope was that any potential decrease in transit ridership will only last until highway gridlock sets in again. A 1981 technical report stated that highway construction was deemed necessary to attend the travel needs of those who would not or could not use transit. The same report also indicated that an expressway would detract close to 3% of the passengers from the adjacent transit facility, but that a freeway would divert much more and its capital costs would be much higher.

The main objectives to be achieved with the LRT investment included the revitalization of the downtown area, the fact that such a wealthy area did not have a "visible" transportation system, and changes in land use patterns (towards higher densities). To a large extent, this latter

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106 Many of the reasons for the dwindling state support came about from disagreements with the freeway portion.

107 Santa Clara County Transit District [1981], pp. 79 and 81.

108 Many of the proponents of the LRT kept arguing about the positive effects of fixed-guideway systems on density patterns in spite of repeated indications that density inducements from that type of transit facilities do not very often come about (Meyer and Gomez-
objective was the one that motivated the decision to select LRT, with the hope that the change the land use pattern would create a high-density commercial corridor 20 or 30 years from now.

This vision was not in harmony with that of the higher level institutions, particularly UMTA. Although the local-UMTA working relationship was termed good by the local people, they also indicated that UMTA had a prejudice, because of an 'East-coast' high-density mentality. UMTA expressed skepticism about the outcome of rail investments in low-density corridors. Therefore, they felt that a system based on buses would be more than enough, and would be more cost-effective (i.e., buses would achieve the same goal at lower cost). Local people, on the other hand, thought that cost-effectiveness criteria were important, but that other elements also counted such as supporting a growing and dynamic economy (with transportation enhancements and potential changes in land use that in turn would, sooner or later, reinforce the LRT project). The busway/HOV alternative was added at UMTA's request, and its technical elements were developed with considerable less in-depth analysis than the LRT alternatives.

The technical reports therefore reflected the enthusiasm for LRT that consultants and transit supporters had at the time of deciding which alternative to pursue. An example of this optimism relates to the estimation of operating costs. Although only raised by a few people, there were some concerns that after coming up with ways to finance the capital

Ibanez [1981]; Altshuler, et. al. [1979]; Hammer [1976]. Others (e.g., Allen [1988]) indicate that rail transit has the potential for changing land uses, but there is no definite study about both the necessary and sufficient conditions for those effects to occur.
improvements, the county will still have to bear the large burden of paying for the operation of the whole transit system once it had been constructed. The 1981 preferred alternative report concluded that for the LRT system farebox revenues would cover 85% of the operating costs. At the end of 1986, when bus ridership had fallen around 3 percent from the previous year, Santa Clara County Transit recovered about 11% of its operating costs from fares 109. (The less optimistic SCVCE 1975 study indicated that no transit option would be able to recover more than 31% of its operating costs from the farebox.)

Some of the advantages of the LRT -- mainly, accidents, safety, and operating and maintenance costs -- were based on achieving the expected ridership. In fact, the preferred-alternative report indicated that "[t]he greater the demand there is for transit (...), the less expensive it becomes to operate light rail transit versus a busway." 110 But if certain minimum levels are not achieved, many of the conclusions of the technical study would not apply any longer, and particularly the adequacy of the selected alternative since other alternatives would largely surpass the LRT option in most of the economic, financial, and cost-effectiveness factors. These arguments underscore the importance of complete sensitivity analysis, where ridership, capital costs, and operating costs are interlinked so that different assumptions suggest different alternatives and levels of investment as well as how much capacity can be provided for a given funding level or, conversely, how levels of ridership would change the economic and

109 Jansen [1987], page 11.

110 Santa Clara County Transit District [1981], p. 23.
financial impacts of each alternative. 

Finally, in the case of the Guadalupe Corridor project, about 200 public meetings were held in the first stage (up to the SCVCE) and about 300 during the process of analyzing alternatives. After such an exhaustive effort, one wonders why so many design changes had to be incorporated later. This paradox arises from the need to compromise many competing interests that never reach a stable position, and the political nature of the project. On October 27, 1981, the Chamber of Commerce indicated that they supported the LRT option, but expressed concern for applying sound business practices, and for loading up the project with "frills" that may be favored politically but do not have a strong impact on the transportation needs in the county. Also, some institutions do not raise their concerns until the moment they have to face them or when their complaints would prove more successful. In addition, the static nature of the technical document does not allow for changes to be made as quickly as they need to be incorporated (or a deliberate passive action is assumed to avoid raising costs too much before the time of selecting the preferred alternative).

All the individuals interviewed agreed that the Santa Clara County LRT project survived the many battles involved in the planning process because

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Furthermore, technical uncertainty was high in this case because LRT technology was relatively new at the moment of the Santa Clara County's transit studies since LRT technology had not been tried to a full scale in other parts of the world (and particularly in North America).
of persistence by major actors to push the LRT technology ahead. Consultants played key roles in the planning and design effort but worked all the times under the technical guidance of SCCTD staff and policy direction of the Board as transmitted by that staff. Community support was always sought, and successfully achieved, by the broad participation program and by the careful selection of components of alternatives to encompass most of the community interests.

3.2.3. Buffalo’s Light Rail Rapid Transit

Introduction

The Buffalo case illustrates issues such as changes in design elements, attempts to redirect land use patterns, and optimistic estimates similar to the Santa Clara County case but from the perspective created by a completely different socio-economic environment. Buffalo’s LRT system was one of the first one to be completed as a new fixed-guideway start in a U.S. city. This newness, coupled with cost overruns and an awkward design, has given Buffalo’s system a somewhat undeserved reputation for bad transit planning and poor management.

Buffalo is a typical example of a mid-size Northeast U.S. city. It is a mature, stable community characterized by relatively high (for U.S. standards) population densities, with a metropolitan population of 1,500,000 in 1980 that had been declining for a decade. Ridership rates (measured by passengers per mile of service) have been above the U.S.

112 The absence of a major supporting actor has been highlighted as the major drawback for the failure to construct a similar LRT system in Denver, Colorado. In fact, the former director of the SCCTD was hired by Denver’s Transit Construction Authority in 1986 to lead another attempt to put ahead a fixed-guideway project in this city.
Since the end of the 1960s there had been a growing interest in a fixed-guideway transit system stimulated by the fact that winter weather in Buffalo includes sporadic periods during which automobile and bus travel is impractical (or even impossible) due to poor visibility and accumulated snow. This interest increased at the beginning of the 1970s as the area's manufacturing base decreased. The fixed-guideway system was seen as a way to revitalize downtown Buffalo and arrest the decline in transit use. The enhancement of the economic and social conditions in the region required commercial and institutional development, but this development was thought to be possible only with significant improvements in the mass transit network.

By the end of the 1970s, Buffalo, New York State's second-largest city, had lost more than 40 percent of its 1950 population. A few miles north, the city of Toronto, which had been involved in the construction of an extensive transit system since the 1950s, was booming economically. With some envy for its Canadian neighbors, local officials perceived the need to revitalize Buffalo's image as a government, financial, and business center. A fixed-guideway transit system would be the shot in the arm to turn around the area's sagging economy. The transit project would provide jobs during the construction period and for years to come through a multiplying effect and extensions of the system. Coincidentally, the federal government was looking for a place to prove the advantages of light rail systems as an alternative form of public transit. Buffalo was one of

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113 The project was many times justified as a question of survival for the Buffalo area.
the preferred choices. The political climate could not have been more conducive to the development of a fixed-guideway system in the Buffalo area. By the end of 1986, a 6.4 mile LRT line was finalized but not before a rather long and tortuous process.

Institutional Environment

Several organizations were part of the transit development process in the metropolitan area. The Niagara Frontier Transportation Authority (NFTA), created in 1967 by the legislature of New York State, has been responsible for the operation of the Port of Buffalo and the Greater Buffalo and the Niagara Falls International Airports, as well as the development and implementation of a unified mass transit program and policy for the transportation district known as the Niagara Frontier region. The Authority acquired and consolidated six of the seven municipal and private bus firms in 1975 and provides for the operation of these bus services through a subsidiary organization, NFT Metro Systems, Inc. NFTA is, in addition, a regular participant in any transportation planning proposals for the area.

At the state level, the Division of Community Affairs in the New York Department of State has the responsibility for coordinating and effecting budget controls for the planning functions of various state departments (including the Department of Transportation), coordinating state planning with planning from regional agencies. The Department of Transportation is responsible for the planning and development of mass transportation and aviation facilities and administers financial assistance programs from the
state and federal levels. The State University of New York at Buffalo is responsible for planning educational and supporting facilities, including utilities and transportation, on its campuses and is concerned with matters outside the University, such as access and egress for students, faculty, and staff.

At the regional level, the Niagara Frontier Transportation Committee (NFTC) is the Metropolitan Planning Organization designated by the Governor as being responsible, in cooperation with the State and NFTA, for the federal (FHWA and UMTA) transportation planning process. NFTC staff reviews and approves final plans for transportation systems in the study area. Assisting the NFTC technical staff is a Planning and Coordinating Committee which includes representatives of the principal technical staffs dealing with transportation in Eire and Niagara counties. The technical work is financed jointly by the New York State DOT, UMTA, FHWA, and the other participating agencies.

At the local level, the counties as well as the cities of Buffalo and Niagara Falls have planning departments involved in transportation matters. From the citizen side, support for major transit improvements became strong at the beginning of the 1970s. During this period, individual citizens and citizen groups, many of whom wanted transit improvements but objected to preliminary designs involving miles of aerial structure, were especially

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114 Capital funds from the State of New York are available to match Federal funds for rapid transit development and bus system acquisition and improvement.
active and able to force the redefinition of the alternatives. Not Overhead Transit (NOT), an aggressive community organization against the construction of an overhead transit system, later became a staunch supporter of the light rail proposals and secured 72,000 signatures on a petition to federal officials to release funds for the construction of an LRT line.

Project History

The initial proposals for a fixed-guideway system in Buffalo date back to 1971. The UMTA-funded 1971 study recommended, among other things, the construction of an 11-mile heavy rail line running from downtown Buffalo northwest to the North Campus of the University in Amherst (figure 3.3). The initial estimates for this line amounted to $241 million, to be funded primarily by discretionary grants (with an 80% UMTA share, authorized under section 3 of the Urban Mass Transportation Act of 1964), and by local funds (20%) administered by the metropolitan transit authority (NFTA).

In the 1971 study, a basic engineering approach to the problem was adopted. In order to minimize capital costs, the alignment was aerial, at the expense of community cohesiveness and growing concerns for environmental impacts. Due to local opposition to the proposed system (the alignment was mostly elevated), a new study (again funded by UMTA) was

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115 Among the ways of participating, the citizen groups inundated the federal agencies with letters of protest, and visits were made to Washington to personally register complaints with UMTA and Congress.

116 A 1969 study by the New York State Office of Planning Coordination already recommended that a rapid transit line be developed to serve future development in the Buffalo-Amherst corridor.
undertaken in 1972. This study resulted in the adoption of a rock-tunneled alignment through the middle corridor and cut-and-cover alignment through almost two miles of the outer corridor. Both decisions were influenced by the very strong concerns of the community and the economics involved. Balancing both long-term and short-term environmental impacts against increased capital costs resulted in the only decision that could be made for rail transit at that moment. The new cost estimates rose to $476 million, mainly because of an 80% increase in the underground section of the line.

Due to the escalating costs (in addition to concerns about ridership figures), UMTA proposed another study where, in addition to alternative alignments, alternative modes were compared and analyzed. The alternatives comprised four bus-based alternatives (one of them equivalent to a "no-build" alternative), several heavy rail alternatives (the benchmark 11-mile elevated HRT, among them), and various combinations (in terms of branches) of light rail alternatives. (Table 3.6 summarizes the capital and operating costs of the most significant alternatives.) The final report came out in 1976 (and the final environmental study in 1977), recommending the construction of a 6.4 mile light rail rapid transit (LRRT) line from downtown Buffalo to the South Campus of the State University in Buffalo (figure 3.3). The estimated cost was $336.3 million (with

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117 Light rail rapid transit (LRRT) is a variation of the more flexible light rail transit (LRT). LRRT provides high level platform, improving system accessibility in general and elderly and handicapped accessibility in particular. Station design allows the elimination of on-board vehicle fare collection. LRT's alignment flexibility is maintained to a large extent by operating, wherever practical, at-grade.
Figure 3.3
Buffalo's Rail Options
Table 3.6
Capital and Operating Costs and Daily Patronage for Selected Buffalo Transit Alternatives
(Cost figures in 1974 dollars)

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Average weekday patronage (thousands)</th>
<th>1995 operat. &amp; maintenance costs ($ thousands)</th>
<th>Capital costs ($ thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Bus (1)</td>
<td>150</td>
<td>$22,300</td>
<td>$75,200</td>
</tr>
<tr>
<td>11-mile HRT</td>
<td>212</td>
<td>$23,600</td>
<td>$373,000</td>
</tr>
<tr>
<td>Maximum HRT (19.6 m.)</td>
<td>224</td>
<td>$25,300</td>
<td>$518,000</td>
</tr>
<tr>
<td>13-mile LRT</td>
<td>193</td>
<td>$26,300</td>
<td>$357,000</td>
</tr>
<tr>
<td>6.4-mile LRT</td>
<td>184</td>
<td>$24,900</td>
<td>$246,000</td>
</tr>
<tr>
<td>11-mile LRRT</td>
<td>212</td>
<td>$23,800</td>
<td>$371,000</td>
</tr>
<tr>
<td>6.4-mile LRRT</td>
<td>184</td>
<td>$24,400</td>
<td>$245,000</td>
</tr>
<tr>
<td>6.4-mile LRRT &amp; Bus (2)</td>
<td>212</td>
<td>$23,600</td>
<td>$336,250</td>
</tr>
</tbody>
</table>


Notes:
1. The advanced alternative combined reserved bus lanes, exclusive right-of-way facilities, contraflow lanes, and traffic signal priority.
2. This was the preferred alternative. In addition to the 6.4-mile LRRT, it included a realigned and rescheduled Metrobus system serving as feeder network for the LRRT line.

Operating costs were estimated at $23.6 million in 1995 with an annual patronage of 63.6 million passengers. These figures were going to provide an operating surplus of $0.6 million by the year 1995. The capital cost estimates were prepared in 1975 by consultant engineers under contract with NFTA. Operating costs were developed in 1975 by NFTA. 119

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118 The $336.3 million supposedly included $22.7 million for improvements necessary to complete an adequate feeder bus network to complement the LRRT. U.S. Department of Transportation [1977], p. 10-33.

119 Incidentally, a careful review of the reports comparing the different alternatives that eventually led to the decision to construct the LRRT line leads to some discrepancies. For instance, the NFTA 1976 conclusions that came to light in February of that year, were...
When the final environmental report was generated, a decision was made to hold train consists to a maximum of four units, in an effort to keep costs to a minimum. This allowed a reduction in station length (to 300 feet), but increased operating costs slightly and reduced system capacity. Another decision made to save capital costs included simplifying the roof and wall architectural design of stations to cover only the middle half of the platform area. For estimating bus operating and maintenance costs, a relationship was developed, based on then-current operating costs in Buffalo, that calculates those costs on a per mile basis, separating costs between those dependent on speed and those that are independent of speed. Further, it was assumed that initial 1982 operating costs would be lower than 1995 levels, by matching patronage with a linear growth between 1982 and 1995. However, the estimated reduction over 1995 levels was proportioned to only 75 percent of the reduction in patronage. For years after 1995, operating and maintenance costs were assumed to remain at the 1995 level. Rail operating costs were developed for the assumed 1995 operating schedules by estimating each major component of the cost individually -- labor, energy, administration, etc. -- and by using employee production values which were based on rail operating experience in supposedly based on the consultant's report that came out in June. Furthermore, the February 1976 report stated conclusions not fully supported in this (June) report. No clear explanation was given by the NFTA officials about this discrepancy in publishing dates.  

For the light rail alternative, they indicated that a key point is that LRT is oriented towards a lower unit capital cost than the heavy rail. Therefore, any characteristics that would prohibit low cost of an adequate LRT facility constituted a constraint.
other North American cities 121.

As to the financial feasibility of the alternatives, the consultants report indicated that "[t]he amount of financing appears impractical to achieve due to Federal appropriation limits." They also indicate that, "[f]urther on the unfavorable side, but less important perhaps, is that inflation is expected to increase the project costs beyond that which the current New York State appropriation would meet even if Federal funds were available, and a further increase in the appropriation in the near future must be rated as uncertain." In spite of these comments, made only for one of the alternatives, and extrapolated to others as "neutral" evaluation, the report did not try to address the issue in more detail. The financing problem, they indicated, can be eased with some reduced alternatives 122.

Even before the publication of the final environmental impact assessment, the head of the U.S. Department of Transportation announced UMTA's "commitment in principle" to the funding of 80% of the construction of the LRRT system. The balance of the total $336 million was pledged by the state. By then, the entire State of New York Congressional delegation was united to press for approval of the Buffalo project, and in addition community groups were putting pressure on Washington. However, UMTA

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121 Interestingly enough, ridership estimation is compared at some point with the case of the "successful" 14.5-mile Lindenwold line in Philadelphia. They proudly stated that the patronage level for the LRRT line was estimated at over three times the patronage on the Lindenwold line. This probably should have raised concern about the estimation process rather than pride.

122 They also stated that a busway branch would offer the opportunity to request highway funds rather than transit funds, therefore making more probable the approval of financial assistance for some transit alternatives. Niagara Frontier Transportation Authority, Alan Voorhees & Associates, Inc. [1976].
indicated that the commitment would be subject to the completion of the necessary environmental and legal requirements. In addition, they stated that the federal share would not exceed $269 million (80% of the estimated total cost) and that it would make a contract with the NFTA only with the assurance that there would be enough money from other sources to cover any cost overruns. NFTA noted that the $336 million project cost estimate included a sufficient allowance for increases in labor and material costs.

The willingness of construction contractors and unions to sign a written no-strike agreement for the duration of construction (aimed at averting cost-escalating work stoppages) and the then innovative proposal to create a downtown transit mall with the LRRT operating on the surface in an auto-free zone were two of the key elements highlighted by UMTA as determinative for the decision to fund the project. But the question of how operating deficits and cost overruns would be met still lingered and some wondered whether or not more thought should have been given at that moment to an overall view of the entire project in the light of scaling down initial proposals (i.e., basically from an 11-mile to a 6.4-mile rail network).

Construction began in April 1979 and was completed at the end of November 1986, four years behind the schedule indicated in the Final Environmental Impact Statement. As the project evolved from the planning to the preliminary engineering, to the construction stage, the NFTA revised its cost estimates. In November 1978, the contract between UMTA and NFTA was signed, indicating a total cost of $449.8 million (with $359.8 million federal share, in 1977 dollars, a sizeable increase from the

\[123\] U.S. Department of Transportation [1977], p. 4-11.
$269.0 million, in 1974 dollars, estimated two years earlier). The estimate was prepared by NFTA and four principal consultants during the preliminary engineering phase.

The Buffalo system was financed under Section 3 statutes by which the federal government would cover 80% of the construction costs. This project was funded, as in the case of Santa Clara LRT line, under the statutes of a full-funding contract. Under this concept, UMTA committed federal funds in specified incremental amounts over the life of the project, subject to the availability of funds from Congress. The federal share could only be increased if certain extraordinary costs were incurred. This concept, by establishing obligation ceilings and grantee responsibility for excess costs, was supposed to be an incentive for the applicants to develop more accurate costs estimates (since cost overruns would need to be covered by the municipality). However, in Buffalo, UMTA assisted in financing additional project costs not included under the provisions of the full-funding contract. Table 3.7 summarizes the evolution of costs and federal contributions. In 1986 a revised cost estimate indicated that the project would cost $534.8 million. Through that date, the federal contribution had been $426.3 million.

Table 1.2 (in chapter 1) summarizes the changes in capital cost estimates that occurred during 16 years of the planning and construction of Buffalo’s rail system and some of the reasons for those changes. Between

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124 Extraordinary costs include inflation beyond that estimated in the contract, natural disasters, eminent domain settlements, federal laws or regulations enacted after the contract award date and that may affect the project, and unforeseen delays in the availability of funds from the Congress. Anything else was going to be the responsibility of the local institutions.
1976 and 1978, underground conditions were surveyed, and detailed plans, including construction schedules and project cost updates, were developed. These plans indicated a 33.8% increase (in nominal values) in construction costs due to engineering changes, delays in starting the service (inflation), increased contingencies, and higher insurance rates. Between 1978 and 1985, the 18.7% increase (in nominal values) was due mainly to unanticipated inflation, expenses incurred in implementing federal regulations, and changes in project scope. Table 3.8 focuses on the LRRT cost growth between 1976 and 1985 based on data reported in a 1986 General Accounting Office (GAO) study.

Table 3.7
Summary of Capital Costs for Buffalo's Light Rail Rapid System (current values)

<table>
<thead>
<tr>
<th>Grants/cost estimate</th>
<th>Approved project costs ($ mill.)</th>
<th>Federal share ($ mill.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic grant application (Oct. 1976, 1974 $)</td>
<td>336.3</td>
<td>269.0</td>
</tr>
<tr>
<td>Full funding contract (Nov. 1978, 1977 $)</td>
<td>449.8</td>
<td>359.8</td>
</tr>
<tr>
<td>Amendments to full funding contract</td>
<td>44.9</td>
<td>35.9</td>
</tr>
<tr>
<td>Total basic grant</td>
<td>494.7</td>
<td>395.7</td>
</tr>
<tr>
<td>Four supplemental grants</td>
<td>31.0</td>
<td>24.6</td>
</tr>
<tr>
<td>Total - all grants (1985 $)</td>
<td>525.7</td>
<td>420.3</td>
</tr>
<tr>
<td>Including art work and start-up costs</td>
<td>534.8</td>
<td>426.3</td>
</tr>
<tr>
<td>Cost of complete estimate (1987)</td>
<td>551.9</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Source: General Accounting Office [1986b], NFTA [1987].
Note: See table 1.2 for additional information on cost changes in the Buffalo case.

Almost 50% of the cost changes could be attributed to scope or engineering changes that had to be made along the way. When considering the utilities relocation and the "unknown," the percentage almost reaches 60%. Most of these changes were later approved by UMTA, -- and hence covered with the 80% federal share -- mainly because the Congress
appropriated funds for assisting several cities in financing the completion of their transit systems.

In explaining why the costs of starting and equipping the system were not included in any of the cost estimates, the 1986 GAO report indicates that: "[a] former NFTA official [stated] that those costs were not included in the initial estimate because NFTA staff did not believe they could determine a cost for requirements that would not be known until much later. Another former NFTA official [indicated] that the costs were going to be included in the estimate for the full-funding contract, but were deleted when NFTA learned that UMTA would not accept a cost estimate over $450 million." 125 Eventually, UMTA awarded $6 million out of the $8 million to cover start-up costs, because UMTA officials thought that was the mandate

Table 3.8
Reasons for Cost Growth in Buffalo's LRRT (1976 - 1985)
(on an amount of $197.5 million = $534.8 m. - $336.3 m.)

<table>
<thead>
<tr>
<th>Cost growth factor</th>
<th>percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering changes</td>
<td>20.3</td>
</tr>
<tr>
<td>Delay in starting service</td>
<td>13.5</td>
</tr>
<tr>
<td>Increased contingencies and insurance rates</td>
<td>15.2</td>
</tr>
<tr>
<td>Utilities relocation</td>
<td>2.1</td>
</tr>
<tr>
<td>Unanticipated inflation</td>
<td>10.6</td>
</tr>
<tr>
<td>La Salle Street station</td>
<td>12.7</td>
</tr>
<tr>
<td>Extension of transit mall</td>
<td>15.2</td>
</tr>
<tr>
<td>Other (start-up activities, station artwork,</td>
<td></td>
</tr>
<tr>
<td>minority business enterprise)</td>
<td>4.6</td>
</tr>
<tr>
<td>Unknown</td>
<td>5.8</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: General Accounting Office [1986b] and own calculations.

125 General Accounting Office [1986], p. 37.
of 1984 and 1985 congressional legislation (as well as the Surface Transportation Assistance Act of 1982).

Another interesting development in the planning and construction process involved a major station on the line. In 1979, the NFTA thought that the La Salle station would not be necessary in light of the expected extension of the system along the Tonawandas corridor (the station was located right at the merging of the Tonawandas branch line with the original LRRT line). In 1981, UMTA approved NFTA's request and the La Salle Street station was dropped from the initial plan of 14 stations, and its funds were transferred to assist in financing enhancements in the transit mall. About a year later, however, NFTA asked that the station be reinstated in the plan, and UMTA eventually funded almost $20 million for that purpose because of congressional mandate. In 1983, the enhancements in the transit mall were also funded ($14.2 million federal share of the $17.8 cost estimate) with discretionary funds because UMTA felt the mall was a worthwhile addition to the Buffalo LRRT project.

Almost two years after the beginning of revenue operation, with an average weekday ridership of 28,000 passengers, the LRRT farebox recovery ratio is 27% compared to 40% for the bus system. The LRRT adds almost $8.5 million to the $24.5 million operating deficit of the bus system, while the annual operating cost per rider for the rail system is $1.0, almost 30% less.

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126 These enhancements included structures for two more stations, a skywalk, and a redesigned square.

127 This measure was approved when Congress passed the Emergency Jobs Supplemental Appropriations Act of 1983.

128 Operating statistics for fiscal year 1987-88, provided by the NFTA (August 1988).
higher than the $0.77 for the bus system. (At the end of 1988, some local officials were even considering the possibility of closing down the underground section of the system, leaving only the 1.2 miles of the transit mall open. This possibility, if implemented, would seriously diminish the initial objectives of the transit project.)

Comments on the Buffalo Case

In Buffalo, the initial conception of the transportation problem as a means to improve the economic conditions of a depressed area was not undermined by the unsuccessful attempt to construct a rapid transit line. The idea evolved into something close to the initial proposal: a light rail transit line with an unconventional design -- with the downtown area at grade and the outer sections underground -- that would give the system some of the operating characteristics (mainly operating speed) of the defeated proposal.

As summarized in table 3.6, an 1977 study provided a set of capital and operating costs (estimated in 1975) in terms of which none of the alternatives had a clear advantage. In fact, if some sensitivity analysis had been performed, none of the alternatives would probably have been significantly different from the others. Interesting enough, the selected alternative, although it considered a rearrangement of the bus system (methodology that should have been followed with the other alternatives as well, but was not), had the same ridership than an almost twice-as-long LRRT, and similar operating costs and a mere 9% less capital costs. (Because of instances like this one, the results of the 1977 alternatives analysis always left room for criticisms by the detractors of the proposals.)
During the planning process, concerns were raised about the financial feasibility of the alternatives, but no major thought was given to these concerns, except for indicating that reduced alternatives could always be implemented (without considering that the benefits of reduced alternatives would probably be much less and their effectiveness very much reduced). The NFTA responded to comments made at public hearings in July 1977 concerning operating deficits, by stating that if sufficient subsidy cannot be provided by all levels of government involved, service in the corridor could be reduced, or system fares raised to make up the difference. This was a very weak argument since cutting down service or raising fares usually leads to further cuts in service and probably larger deficits. The careful examination of alternative scenarios in relation to which level of demand may turn out to be attracted to the system did not receive careful consideration. Furthermore, scaling down initial proposals should have required a whole reexamination of the project, since the same set of assumptions does not hold for two systems with different lengths, different levels of service, or different technologies.

It is also important to note that in this project, the preoccupation with cost overruns probably distracted attention from more basic design elements. For instance, in spite of the half a billion invested in the project, no provision was made for conveniences for LRT drivers. Currently, drivers have to request permission from the central control operator to leave the car and enter any open building in the central area looking for restrooms (buildings that may be particularly hard to find during late evening hours or weekends). Another example is the location of the crossover at the South Campus terminal station. The crossover is
located before the station, and since at the crossover the speeds must be much slower, it causes delays and reduces the capacity of the line, particularly during peak periods. Finally, in order to attend the needs of handicapped passengers, stations in the at-grade section have an elevated platform to serve the first door of the car. The LRT car has high floors, but for those doors outside the platform area, some steps must be released for people to get on and off. The whole operation requires considerable dwelling time at each of the six stops in the at-grade section, further reducing the capacity of the system.

As major obstacles to the accomplishment of the project within the budget initially estimated, local officials mentioned (a) uncertain funding from the federal and state governments, (b) disputes with the city over relocation of waterlines, unexpected vaults and telephone systems, and (c) inaccurate utility maps. Nevertheless, the 60% cost change due to design elements (table 3.5) is a fairly large number for elements whose uncertainty can be reduced with additional and careful analysis (unlike other elements such as inflation that fall beyond the control of the analysts). Some of the increase in costs were due to enhancements incorporated into the system to attract additional passengers such as art work. Even by these accounts, however, the project can not justify some cost increases since several other planned amenities, such as an ice-rink and a laser show, have not been implemented. (Buffalo's LRRT case has become a well publicized case of cost overruns although, once cost figures are corrected with inflation, as indicated in figure 1.1, the overruns are

\[129\] These steps are activated at the request of passengers, who must press a button located to either side of each door.
not more dramatic than in other less publicized instances.)

The decision to construct Buffalo’s LRRT system came from many sources but most of all was motivated by the sagging economy in the area during the 1970s. The strong and united congressional delegation, with one of its members chairman of the appropriations subcommittee of the transportation committee, helped overcome some technical hurdles and secured the necessary funding. Once again, the presence of persistent advocates for the transit system kept the project alive beyond the results of the technical analysis. Hence, the role of this analysis as the critical element in making decisions became rather curtailed.

3.3. Case Studies Abroad

This section relates the author’s experiences in countries outside the United States. Without any attempt to carry out a full comparative analysis of transit-project planning, this section discusses other elements of the technical and decision-making processes that can help understand the interaction between these two processes and elucidate some of the issues presented in the U.S. case studies.

As mentioned in chapter 2, the major difference between the U.S. and other countries -- particularly European countries -- is that, in the U.S., transit faces an often inhospitable environment where highway and automobile interests subdue transit initiatives on most fronts. Moreover, unlike transit in Europe, which has been mostly motivated by and linked with urban growth and development, U.S. public transit has been more

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130 Whitt and Yago [1985]; Whitt [1982].
the result of political pressures and pork-barreling 131.

In the U.S., transit programs used to emphasize ridership and are now more concerned with costs of producing service. In Europe, by contrast, transit programs emphasize the quality of service provided such as accessibility, in terms of frequency, reliability, speed, and transfer requirements, and comfort and safety. This does not mean that the cost of producing service is completely neglected, but rather that its assessment occurs more in relation to the potential benefits generated from service changes or capital investments 132.

Another difference between transit planning in the U.S. and other countries is the degree of formalization of the technical and decision-making processes. These processes are much more formal in the U.S. where precise federal regulations have been developed to select the preferred transit alternative in those cases seeking funds from the federal government (see chapter 2). In other countries, these processes are more of an ad-hoc nature with minimal statutory requirements that are only generated as the projects come along 133. These characteristics will be reflected in the next two case studies: Madrid’s rail transit network, and La Paz’s transportation proposals.

131 Fielding [1983a], page 289.

132 It must be mentioned that the difference in emphasis arises because of the distinct predominance of transit in attracting urban trips. In the U.S., this predominance is very low outside a few major metropolitan areas, and consequently transit planning is approached from a different perspective.

133 This aspect reflects the more general fact that local governments are more trusted and authoritarian outside the U.S.
3.3.1. Madrid's Rail Transportation System

Introduction

This case study does not focus on a particular project (since it was hard to single out one that could be followed from the beginning to the end, and that had characteristics similar to the ones selected from U.S. cities), but rather on the institutional structure, planning process, and development of fixed-guideway systems in the Madrid metropolitan region. The case study illustrates a relationship between the central government and local institutions where politics also play a major role but that, at the same time, tends to eliminate some of the mistrust that exists in the U.S. context and attempts to incorporate incentives that encourage outcomes closer to those estimated in the analysis process. This situation largely originates in the characteristics mentioned in the previous section. Nevertheless, how the planning process is structured in the Madrid case has some application for the U.S. context.

Madrid's metropolitan area had a population of almost 4.7 million people in 1986, up 27% since 1970. In 1981, the number of trips on foot amounted to almost 58%, while 29% were done by transit and slightly less than 14% were done by private modes of travel. Nonetheless, the 1980s saw a dramatic increase in the registration of private automobiles, after a downward trend at the end of the 1970s. A declining economy at the end of the seventies and the competition from private modes of transport at the beginning of the eighties caused the steady decline of transit patronage since 1974, with most of the decrease taken by the subway network while the

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134 These fixed-guideway systems are of two kinds: the subway system, a 10-line, 104-kilometer network, and the commuter rail system, a 9-line, 241-kilometer network.
bus network held a slight increase. In 1985, however, transit ridership rebounded with noticeable increases along with the improvement in the overall economic conditions of the country.  

The institutional framework has undergone remarkable changes for the past 10 years as the "Community of Madrid" obtained statutory responsibilities over transportation matters -- in addition to education, public health, etc. -- and formed its own regional government, aside from the municipal government which had the responsibility for the planning and operation of the bus network. Nevertheless, for major investments, both the regional and the local government have always had to request funds from the central government. Hence, transportation investments have been the product of the interplay of four primary sets of actors: the central government, the regional government, the municipal government, and the transit operators.

**History**

The subway system started as a private venture in 1917. The company paid for any investments in infrastructure of the subway system until 1956. In this year, the central government, through its Ministry of Public Works, assumed the task of financing any additional infrastructure (and constructed line 5 ¹³⁶) in light of the impossibility of the private company to undertake any further capital investments. In 1978, mainly due

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¹³⁵ Conserjeria de Politica Territorial [1988], pp. 5-7.

¹³⁶ The subway lines are labelled with numbers in Madrid's subway (e.g., line 1).
to the deterioration of service 137, the central government took over the company, and an "Intervention Council," reporting to the Ministry of Transports, embraced the role of manager of the company 138. The members of the Council were designated by the Ministry of Transports. At the end of 1978, the central government proceeded to buy the shares of the company from its shareholders by exchanging them with shares of the national telephone company or by expropriation. (This decision was to be approved only if 60% of the shareholders, as eventually occurred, accepted the exchange of shares.)

Between 1978 and 1986, when the company became a part of the "Consortio Regional de Transportes" -- the metropolitan transportation agency that was part of the Madrid regional government ("autonomia de Madrid") 139 --, the central government was in charge of every investment in the system, except for those regarding the rolling stock. This equipment however could be acquired only with the warranty of the central government. This government was to pay for any operating deficits as well, as far as the fare had to be subject to controls for reasons of public interest.

Between 1978 and 1986, the network almost doubled its 1970 length of 54 kilometers. A plan developed in 1967, and later revised in 1971 and

137 Several dramatic accidents, with deaths of passengers, took place during this period, precipitating the intervention of the central government.

138 There was one line (line 10) that became part of the municipality of Madrid, being managed however, as part of the whole subway network, jointly with the subway company.

139 Madrid is one of the 17 regional governments that were instituted in Spain during the first half of the 1980 decade. The region includes the territories of the former province of Madrid.
1974, envisioned a network of 139 kilometers. In 1984, the length became 104 kilometers, with no immediate plans to keep on with the same pace of investments, due to declining ridership. In 1987, with the change in ridership trends, plans for increasing the network were revived. If these plans were implemented, the network would eventually achieve its 1967 goal of 139 kilometers.

The lines opened during the 1978-1986 period were substantially different from the old lines. The width of the tunnels and stations, as well as the length of the latter, were larger. Vehicle comfort was improved. However, in order to economize in construction costs (by avoiding complex structures to support building foundations) and due to the strong rolling topography along the suggested routes, the lines were built deeper underground. This design created some problems at the transfer stations with the old system. Overall the new lines increased operating costs and created longer access and transfer times, which initially were the reasons for the low utilization of the new, high-standard lines. Idle new rolling stock (almost fifty percent of the new vehicles, during the initial periods when the new lines presented low levels of ridership) could not be used in old lines because the cross-sectional tunnel clearance for the new vehicles was wider than that available in the old lines.

The purpose of the creation of the transportation consortium was to rationalize the transportation system and avoid the duplication of service and competition between the bus, subway, and commuter rail network.

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140 Ridership decreased from 518 million passengers in 1970 to 332 millions in 1984.

141 In 1986, ridership in the metro system increased by more than 2.5%. A similar increase occurred in 1987.
However, the consortium was created from the ownership of the subway company, while the bus system remained in the hands of the municipal government, and the commuter rail system stayed within the domain of the national railway company. In addition to lack of coordination in areawide planning, the institutional setup created a bias towards investment in subway assets -- reflected in the technical studies carried out by the consortium\footnote{In fact, except for some studies for the integration of fare systems and others for demand estimation, most of the technical studies refer to extensions of the subway network (Consorcio de Transportes de Madrid [1987]). For instance, the last strategic document indicated that "the metro, transportation mode of high capacity, is the principal receptor of the trips generated at the periphery of the city, and the basic mode for the connections inside it." Moreover, recent attempts to rationalize the bus system confronted a strong opposition from the bus company, with any actions by the consortium being questioned in legal terms.} -- as the new transportation agency in charge of the subway network -- the consortium -- tried to establish a significant role in the city's transportation matters.

Two projects can be cited as having been the subject of considerable controversy: the extensions of line 1 and line 6. The former was a prolongation of the subway line towards one of the poorest neighborhoods of Madrid (the neighborhood of Vallecas); the latter was meant to be the first step towards the closing of a circular line.

In the case of the extension of line 6, its economic feasibility (and hence, the opening or closing of the line to revenue service after it had been built) switched from positive to negative depending on the philosophy of the times based, for instance, on what monetary value was put on travel time. In addition, the technical studies had some fundamental flaws. For example, at the time of calculating costs, no consideration was given to
the additional capital and operating costs that would be necessary for the extension of the line in terms of rolling stock, and the necessary improvements in the signalization -- to allow for automatic train protection and automatic train operation. Other controversial elements were the number of ticket booths, for which only the energy costs were considered.

At some point, the vice president for operations and capital programming did not support the opening of the extension of line 6 because he believed that, considering the demand for buses running on the same corridor -- even in mixed traffic --, the system would not be economically feasible. Negative rates of return further made this actor cautious about opening the extension. The next vice president, with a more expansionist view of the service, opened the line to revenue operation with a good degree of success (in terms of ridership and public acceptance). It turned out that demand involved not only people that formerly were riding buses but also a considerable amount of pedestrians (mostly students) going to the last stop of the line (University City) who, in the initial studies, were thought to be unwilling to use the subway line for relatively short distances.

In the case of the extension of line 1 (still under construction), the final decision as to what mode could best serve the needs of the corridor, was labelled "political" by the technical director of the regional consortium. Vallecas was a marginal neighborhood with a single umbilical cord linking the neighborhood to the core of the city (across a bridge).

Footnote 143: For explanation of this technological terminology see, for instance, Vuchic [1981], pp. 437-444.
Central and local politicians had promised a subway line to improve the transportation services in the area. Several modes were analyzed, and finally, mainly through the manipulation of the values for the time benefits, a subway option was selected as the optimal one. The technical study, carried out by the regional consortium with the collaboration of outside consultants, concluded that the extension of the line was not feasible although the consideration of other elements that were hard to quantify -- such as the better integration of the neighborhood into the structure of the city and the savings in the consumption of non-renewable energy sources, since the subway used electricity instead of combustible fuel -- would probably help justify the construction of the preferred alternative.

This process illustrates the interaction of the institutional actors in order to keep afloat the subway network, the consequent effects in the analysis process, and how this process reflected different investment philosophies at different moments. These elements can be further analyzed through the investigation of the "program contract" with the central administration, developed some time before the Regional Consortium took over the ownership of the company and its management. The program contract is the contract signed by the funding institution (the central government) and the transit authority where the elements of the project and the conditions for the transfer of funds are specified. This contract reflects the compromises between the central and the regional governments in order to finance the operation of the system as well as any new investments in

\[\text{The value of an hour of travel time had to reach at least } \$7.00\text{, in 1987, in order to balance social costs and benefits, for an area where incomes were below an average of } \$4.00\text{ per hour.}\]
the system. Another program contract, that of the agency in charge of the planning and operation of the commuter rail network with the central government is also discussed in the next paragraphs.

Program Contracts

The 1985-88 program contract between the subway agency and the central government highlighted the objectives to be achieved during a period of 4 years (1985-1988). The fundamental objective was to increase the quality of service as -- it was stated in the contract -- the only way to attract automobile drivers and reduce the congestion on the city streets. In addition, the program indicated the intent of increasing the coverage of operating costs, or farebox recovery ratio, from the 50% existing in 1984 to 70% by 1988. The contract was signed by two ministries of the central government (the Ministry of Economy and the Ministry of Transportation), the president of the Community of Madrid, and the Mayor of Madrid in representation of the subway company 145.

In the program contract, elements such as the number of vehicle-kilometers to be provided, productivity levels, and the fare level were specified. Furthermore, the program indicated that if in achieving these operational goals (and the broader objectives previously mentioned), operating deficits increased, the central government would adequately compensate the agency in charge of financing the subway system. These compensations were estimated and shown in the program along with capital investments to be covered by both the central government and the Community

145 The regional transportation consortium was not created until 1986. Therefore, the program contract was signed by the subway agency in charge of the planning and operation of the subway network ("Compañía Metropolitano") or its representative.
of Madrid. Both the operating and capital compensations by the central government would be taken out of the central budget and, in the event they had not been properly appropriated, the central government would create the necessary legislation to provide the funds.

The investments would be managed by the Community of Madrid (through its Regional Transportation Consortium, whose creation was already considered in the program contract) and the participation of the central government (through its General Directorate for Infrastructure Investments) and the subway company. A commission composed of officials from the Ministry of Economy, Ministry of Transports, Community of Madrid, and the subway company meets quarterly to monitor implementation of the program. Quarterly reports would indicate the degree of compliance with the objectives and the causes for deviations. Every year the commission could suggest updates to the program depending on the changes in the overall environment (e.g., general macroeconomic trends that had led to the specification of objectives and their technical descriptors). In the event of non-compliance, the commission would inform the central government and would propose which actions to pursue 146.

For the case of commuter rail services, the process is somewhat different since Madrid's commuter rail system is a part of the national railway company -- "Red Nacional de Ferrocarriles Españoles" (RENFE) -- and not of the regional consortium. This unusual situation is the result of historical factors, since the property of the commuter-rail trackage and equipment has belonged to RENFE since the initiation of the system. RENFE

146 The program, however, is not more specific than this about what to do if non-compliance with initial objectives occurs.
in its turn is financed and managed by the Ministry of Economy and the Ministry of Transport. The company therefore must report to these two ministries, and these two ministries provide the funds necessary for the operation and capital investments of both the intercity and commuter rail systems (for passenger and goods movements).

Developments in the commuter rail network are also guided by contract programs between the interested institutions: RENFE, the Ministry of Economy, and the Ministry of Transports. The 1988-91 contract program covers a period of 4 years, and establishes the objectives to be achieved (in terms of number of passenger-kilometers or service reliability) as well as some incentive mechanisms to reach these objectives. The central government covers all the operating deficits and the costs for the maintenance and amortization of infrastructure based on the rationale that the service is a public service and therefore of general interest to the public. The capital investments to be realized during the four years of the contract are also specified, indicating which institution will be in charge of carrying them out.

This contract program for the commuter rail service includes some interesting incentives to achieve the specified objectives. The contract indicates that if the expected number of passenger-kilometers is surpassed, the subsidy level for that particular year will be augmented by 3 pesetas (about 2.6 cents at the 1988 exchange rate) per passenger-kilometer. On the other hand, if the number of passenger-kilometers is 10% lower than the expected value, the subsidy will be reduced in 3 pesetas per passenger-kilometer of the difference between the actual number of passenger-kilometers and the expected value (the one estimated in the contract
program) reduced by 10%. The process of measuring the number of passenger-kilometers in a particular year will be verified by a special official of the Ministry of Economy.

As in the case of the contract with the subway company, there is a supervisory commission, with officials from the two interested Ministries and from RENFE, in charge of controlling the compliance of the program contract quarterly, and proposing the necessary updates to the program.

Comments on the Madrid Case

The overall development of Madrid's subway and commuter rail networks reflects the different philosophies about transit services associated with different periods of time and with different actors. At the end of the 1970s and beginning of the 1980s, the retrenchment philosophy -- if service is bad, it must be cut down -- was prevalent. The main goal was financial soundness. The pursuit of this goal reduced the quality of service, further reducing the demand for it and encouraging additional cuts. In an attempt to end up with good financial results, the retrenchment philosophy could cause the whole system to close.

On the other hand, the expansionist philosophy, prevalent in the mid-1980s, stated that only through increases in service quality, including higher frequencies and additional investments, could the system attract new riders and, although deficits might increase, the overall social-economic value would increase. According to this rationale, deficit increases were qualitatively lower than increases in the number of passengers and in service quality. This philosophy emphasized quality of service as the major thrust behind the provision of transit services.

In any case, transportation officials regarded the subway and commuter
rail network as a public service that, due to this character, had limitations on how much to charge passengers for a trip (i.e., the fare level). The operating agency, hence, does not have to make a profit, but rather must focus on a marketing strategy to attract as many passengers as possible, leaving the coverage of deficits to the general government (to which corresponds the policy of cross-subsidization so that low income people can cheaply travel within the metropolitan area) \(^{147}\). The strong emphasis on the service as public service led to easier backing of transportation investments by the central government. This situation also arose from the dominance of Madrid as capital of the nation (compared to a situation like the one in the U.S. where the weight of a particular city in the federal machine is much lower) and the stronger willingness of the central government to participate in local affairs.

The projects about the extension of lines 1 and 6 explicitly indicated that the projects were not economically feasible (and for which reasons) and pinpointed those other elements that could be incorporated to make the project worthwhile (for instance, if a monetary value were given to the integration of marginal neighborhoods into the structure of the city or to the savings in the consumption of non-renewable energy sources). These explicitness favored a strong acceptance of particular roles by the different actors involved in the transit planning process, with the

\(^{147}\) A key item in the strategy is that the government agrees on keeping fares low so that low income people can travel within the city, even though middle and high income people can also benefit from the strategy. In European cities, where the distribution of the population consists, in contrast to the U.S., of low income people living in the outskirts of the city and high income people closer to the center, the issue of subsidization of transportation services, by keeping fares low, plays a more clear and important redistributive role than in the United States.
assumption that the technical studies were carried out only for the purpose of informing decision makers.

The program contracts (for four-, five-year terms) represent examples of the ad-hoc nature of the transit project planning process and, at the same time, the means to handle uncertainty. Transportation officials interpreted them as an expression of the negotiations among the interested parties and the compromises achieved among them. The contracts are rather specific, in terms of specifying thresholds to be reached or monetary amounts to be spent, and at the same time rather flexible because both parties (i.e., central government and the institution in charge of the construction and operation of the fixed-guideway system) want to have the possibility of adapting the contract to new circumstances and conditions. The transportation agency wants to be able to experiment and have some leeway as transit entrepreneur. The central government, mainly for political reasons, wants to be able to adapt objectives and play with the program contract at the broader level of the central budget. Hence, the contract contains different levels of specificity and additional clauses for how to review and update it. The contract usually extends for a period of four or five years, during which the actors know the amount of funds available for investments and for covering operating deficits and which thresholds they must strive to achieve. Nevertheless, these programs, by focusing on particular modal investments (e.g., the subway network) at particular times eliminate much of the (transportation) planning at a broader (metropolitan) scale.

Another interesting element of the program contracts consists of the possibility of incorporating incentives to carry out unbiased procedures
and to achieve specific operating objectives. Although it is too early to assess the effects of these contracts on investments and operating practices of Madrid's rail network (and on the accuracy of cost estimates), in principle, incentive mechanisms -- such as the premiums for passenger-kilometers above the expected value and penalties for passenger-kilometers below the expected value -- should induce transit planning and operating agencies to take into consideration all the possible elements that would affect costs and account for potential variations in their values.

What are the implications of all these elements to costing methodology and estimation? First of all, the "welfare policy" philosophy shifts the emphasis from the cost components to what is needed to make the project worthwhile and the overall benefits of the investment. For instance, the results of the feasibility study for line 1 were focused on the value of travel time. The feasibility of the project depended on the assumption the decision maker wanted to make about the value of travel time. On the other hand, the "welfare policy" philosophy may overemphasize the benefits associated with intangible objectives -- such as the physical integration of communities -- regardless of how important they are in reality (as compared to other societal objectives). This overemphasis may lead to the loss of some concern with cost-related issues such as functionality, operational design, or cost-effectiveness. In other words, incentives to economize -- or "design-to-cost" \(^{148}\) -- may be lost. Second, the actors' clear notion about their roles and the incentive format of the contracts seem to favor a more transparent and less politically-biased technical process, as decision makers do not try to influence analysts and analysts

\(^{148}\) This concept will be further discussed in chapters 5 and 6.
do not easily give in to the pressures of decision makers. Finally, the strong backing of the central government seems to encourage a less beleaguered technical process with less distrust and less motivation to distort it as decision makers do not feel the need to maneuver to secure a share of central-government funds.

None of the projects discussed in this section have been completed yet. Unfortunately, therefore, there is no way to know what the actual effects of the approach initiated in Madrid's transportation planning process have been in terms of the "correctness" of the technical analysis (e.g., how accurate capital costs ended up being). Nevertheless, this case study illustrated an approach to frame the relationship between the central government and the local institutions that attempts to eliminate mistrusts and incorporate incentives to encourage outcomes closer to those estimated in the analysis process.

3.3.2. La Paz's Transportation System Study

Introduction

The La Paz case study presents a situation where the political environment clearly attempted to override the technical process. This situation generated communication difficulties between decision makers and analysts as far as these analysts tried to maintain some professional neutrality (e.g., tried to defend their own technical approach even if this approach did not support the proposals advanced by decision makers). The case study further illustrates the link between the institutional environment and the analysis process, and how the latter must be tailored to the conditions of the former should analysts wish to play a role in the
Bolivia, one of the poorest countries in Latin America, has the area of Texas and California combined and the population of Georgia (around 6 million). One million people live in the capital city of La Paz. The city is located in a valley in the middle of a plateau at almost 12,000 feet of altitude, with its center at the bottom of a valley and neighborhoods spreading over the steep slopes surrounding the valley. During the past decade, due to topographical constraints, the city has been expanding on the plateau where the largest portion of the population now resides. Transportation between this area and the center of the city is difficult, with no easy way to travel between both places. At the present, besides walking the steep grades, people can only travel by bus. Travel by bus between those two places, however, takes a long time, with waiting times exceeding one hour during peak periods.

When a new mayor was elected in December 1985, one of his priorities was to improve the transportation system of the city. He had the idea (probably generated by one of his assistants) of constructing an aerial tramway to link the neighborhood on the plateau with the center of the city. In addition to helping reduce travel times (and probably improve travel comfort) between these two neighborhoods, this transit system would give him a highly visible political achievement. The electoral process (with the mayor being elected every two years) creates a lot of pressure to implement policies and construct visible infrastructure investments in a quick fashion; the aerial tramway could easily help alleviate this pressure.

The institutional environment included the following actors: (a) the
executive branch of the municipality, with the mayor at its head; (b) the city council, where the mayor had a meager majority, and therefore risked losing any proposals; (c) the consultants, with different groups advocating different types of transportation technologies and approaches; (d) the providers of transportation technologies, with an interest in making inroads into a city with such peculiar topographical conditions; and (e) the high level financing institutions, mainly the World Bank, with an interest in getting a sound financial return from transportation investments, particularly in those projects that were capital intensive.

**Project History**

During the Fall of 1986, the author was involved in developing a feasibility study for a public transportation system in La Paz. The transportation system of this city was in disarray, with travel times for some segments of the population well above average levels for developing countries. As a major World Bank project was carried out (including investments ranging from sanitary systems to structures for disaster prevention), World Bank officials also requested an analysis of the best modal technology for the city. In addition, the mayor's political agenda, with a horizon of only two years, acted as catalyst for undertaking such a study. This was mainly because to construct any major transportation investment (and particularly the aerial tramway) some outside financing would be needed and the feasibility study could serve as a good analytical support for the benefits of such an investment. Finally, the need for a highly visible investment and the particular physical characteristics of the city (with very steep slopes between the most populated neighborhoods) made the consideration of novel technologies (e.g., aerial tramways) an
attractive element in the analysis.

Before the study was undertaken, a preliminary study of the feasibility and suitability of an aerial tramway system was undertaken by a team of local consultants under the direction of the assistant to the mayor during the summer of 1986. Due to lack of information, this team developed an approach based on information submitted by the manufacturers of the aerial-tramway technology. The informal study indicated that the aerial tramway would be, by far, the best alternative in terms of comfort, capital costs per passenger, and operating costs. The study did not attempt to carry out a whole set of technical and financial analyses. With this study, the local team attempted to persuade the high-level institutions of the desirability of constructing the aerial tramway. Simultaneously, the team developed the terms of reference for an international bid. It was evident from the reading of this document that the assistant to the mayor had a vested interest in building an aerial tramway (instead of any other alternative) because, as an architect, he was in charge of designing and constructing the three stations proposed for the system. The team that he directed, therefore, followed a rather optimistic approach in estimating the capital and operating costs associated with the system (mainly in terms of which costs to include and the use of operating performance figures like headway, vehicle utilization, etc.).

In September 1986, a team of foreign consultants, which the author was a part of, was assigned the task of carrying out an in-depth feasibility study of several alternative modes including the favored aerial tramway.

149 The bidding document was hidden from other parties, to avoid any complaints about it. The mayor allowed the author to look at it for the purpose of making comments on the document.
In pursuing a broader appraisal of the transportation conditions of the city, the first problem was data collection. Census information was poor and the team had to design its own estimating process to generate an approximate figure for the transportation demand in the horizon year (1990). Population figures for the different neighborhoods of the city and other socio-economic information dated back to 1974 with very rough extrapolations made to the year 1985. The study team developed a process for estimating the densities and the approximate population of the census tracts of the city based on cartographic information and aerial views of the city. Based on these data, the visual inspection of each area, and conversations with various officials, transit demand was calculated and, based on that demand, so were the fleet requirements for the different alternatives. Similarly, capital costs were not available, and operating cost figures provided by the municipality were unreliable. By comparing the figures with similar systems in other places, the team was able to estimate the capital and operating costs of the different systems. For the aerial tramway, the task was the hardest, since the information provided by the manufacturers of the system had to be looked upon with suspicion. A computer-based spreadsheet model of the financial consequences of constructing and operating each of the alternatives was created. With this model, sensitivity analyses were carried out to better perceive the changes in output values as input values diverged from the initially assumed values.

The team of foreign consultants enjoyed, on the one hand, a lot of freedom in terms of how to approach and undertake the feasibility study. On the other hand, the closeness to the decision making point created some
difficulties, in terms of trying to address the study with a reasonable level of professional objectivity. From the decision making perspective, the goal of the study was very clear: to justify an investment so that it could be approved by the city council and funded by the higher level institution -- i.e., the World Bank. The consultants selected an open-ended methodology in order to allow for discussion, negotiation, and compromise. The reason for such an approach was mainly due to the fact that the study in itself did not matter to the most interested actors: what mattered was its results, particularly those that supported the decision maker's goals and perspectives.

In a very dynamic institutional and political environment, the analytic process had to be carried out within a short period of time and a lack of reliable sources of data. The large use of secondary sources of information, was encouraged by that institutional environment. There was not a strong need for high precision in the estimates due to the purpose of the project and the tense atmosphere surrounding it. The large use of sensitivity analyses was to compensate for the lack of a more orthodox process and to control for the uncertainty of the estimates. The objective of the sensitivity analyses was to define some ranges of decision. By varying the values of the variables that were thought more critical, and generating graphs reflecting changes in the values of one variable as the value of another variable was changing, the different transportation systems were compared to one another.

Within the technical process, the main uncertainties were related to productivity measures for the particular conditions of La Paz. This was particularly acute in the case of the aerial tramway, because, due to its
novelty in an urban setting, it was hard to find relevant information from other places in the world. Another technical uncertainty was the requirements for maintenance costs. The model simply applied a percentage over the investment level. These percentages were the same within the same technology but not across different modal alternatives. For operating costs, some items like energy costs were highly reliable, but others, like labor costs, were more problematic because, as before, productivity levels (e.g., how many operators were needed to operate a particular transit system) were not well documented. Similarly, insurance costs were hard to estimate, since the insurance market was not well developed in the country.

In spite of the methodology's theoretical shortcomings, the major disagreement between consultants and decision makers centered not on the methodology but rather on which items to include in the cost equations and which values to assign as cost units for the different items of the capital and operating costs. The bids and quotations from the manufacturers of the different transportation technologies were not clear at all. In particular, it was not clear what was included and what was not. For instance, it was not clear whether the costs of some of the components were in-situ and therefore included the transportation costs or were costs at the manufacturing place. The consultants reduced some of these discrepancies.

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The methodology from a theoretical standpoint had some shortcomings. For instance, it did not try to carry a full demand analysis, taking into consideration changes in demand as the fare level was changing (elasticity studies). It did not consider cost contingencies either, and no distinction was made between local and foreign goods. Furthermore, it was thought that after 20 years the value of the inputs variables was highly uncertain to receive further consideration and, hence, the methodology did not try to consider similar useful lives for all the transportation alternatives.
by comparing bids among the different reports provided by the manufacturers. Nevertheless, a final agreement on these matters could not be reached and was only partially solved through the use of sensitivity analyses.

The La Paz transportation study came about largely as a response to the needs of the political actors (i.e., mainly the mayor of La Paz). Therefore, the preferences of the key decision makers had been spelled out well in advance the study was underway (as various international bids had already been requested ten months before the study began). This situation created strong difficulties in the technical analysts' attempt to "objectively" influence decision makers' perceptions about the solutions for the transportation problems in the city. As the study evolved, these perceptions did not substantially change but the decision makers' contentions about the advantages of the aerial tramway shifted from one based on the cost advantages of that alternative to one based on the need for some innovative project, something courageous, that could raise the standards of the city and the illusions of its citizens.

Comments on the La Paz Case

The La Paz case illustrates a situation with a strong political motivation, a zealous and biased interest for a particular technology (to the extent that the decision about the preferred alternative had been spelled out well before the feasibility study began), and a need for outside help to gain credibility for the project and acceptable financing terms. The decision-making environment included the mayor and the city council, and the leverage that the approval from an internationally recognized institution -- the World Bank -- would have given the project.
Other interested parties included the manufacturers of the technologies and the local architects, with a visionary view of the city and its transportation system, likely to be in charge of designing the system (particularly stations). To put his preferences forward, the mayor needed a strong "support" behind any major transit proposals. This support would be particularly effective if it could come in the form of qualified technical analysis, and if possible from highly recognized sources.

The decision making environment was highly centralized around the two-year-term mayor. However, to proceed with a proposal the mayor needed the statutory approval of the city council, to which the justification for a project had to be reported. In addition, the mayor's decisions were highly limited by the financial capacity of the municipality to undertake large capital projects. Overall, the two-year term and the decision-making process prompted the mayor to devise ways to generate projects which were both feasible and visible, and generated an inducement to influence the technical process.

The characteristics of the situation, therefore, required the development of a technical process with a level of flexibility that allowed adaptations to be made on the spot, responding to the dynamic nature of the institutional framework. This need for flexibility was, in addition, required by the low reliability of the input data. Hence, the transportation-feasibility model consisted of several integrated modules \(^{151}\) with a high level of transparency (in terms of clearly showing assumptions, inputs, methods, and outputs), and included the thorough

\(^{151}\) The modules included: demand analysis, fleet requirements, cost assumptions, and financial analysis.
development of sensitivity analyses. The computer-based spreadsheet environment help achieve these components and allowed for quick changes in the input values and model assumptions.

The interested parties reacted to the feasibility analysis by looking at the model as a black box. This was mainly due to a lack of technical knowledge and the novelty of the use of computer technology in the municipality for analysis and decision-support purposes. The model quickly became the tool to justify the objectives of the decision-making process. Pressure centered on changing input values (mainly cost estimates) so that the preferred alternative (the aerial tramway) would be more feasible compared to the other alternatives and even show operating profits.

In spite of the pressures, the transparence of the model and the clear stating of its assumptions forced the decision maker to realize about the tradeoffs involved in constructing one alternative versus another and the dangers (mainly in terms of financial obligations for the municipality) that the undertaking of particular alternatives would bring about. This evidence was reflected by the shift in the stated advantages or disadvantages of particular alternatives that move away from cost-effective measures to less quantifiable elements such as the perception that the aerial tramway was the only breakthrough option to improve the transportation conditions of La Paz (and, one could possibly add, the

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152 The study further qualified the model by discussing the issues of institutional capability to carry out the necessary maintenance tasks, and the problems of integrating each alternative within the existing transportation system. In addition, the comparisons between the fare needed to cover operating costs for each alternative and the income levels in the city clarify the potential feasibility of attaining revenues and meeting the specified demand. (Beteta and Menendez [1986])
mayor's chances for reelection).

At the end, the analysis process proved useful to change the initial impressions about particular technologies, generate new ideas about the city's transportation issues, and redirect the decision makers' perception about the problem (although the mayor still continued to support the "preferred" alternative). The case exemplifies the experience on how to undertake an estimation process in a highly politicized environment, and how such a process can be constrained by time limitations, data collection problems, and institutional pressures. The design of the estimating process, and the computer-based model, attempted to address the ultimate function of the study: to compare different alternatives and serve as a locus for the technical and decision-making processes to interact. The experience proved that, among other factors, the transparency and flexibility of the planning process can help the interaction between the analysis and the decision making processes. Such a process can also help actors to zero in on the rationale for a transportation project, its possible solutions, and its valuative criteria.


This section summarizes the characteristics of the decision-making and analysis processes that can be drawn from the case studies. These

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153 Three years after the study was finished, and after tying the local elections of December 1987 (and splitting the two-year term with the other candidate), the mayor kept, unsuccessfully, trying to secure funds for the aerial tramway. In his December 1989 campaign, he still advocated the construction of the aerial tramway. Although he lost the 1989 election in percentage votes, he secured the sufficient support at the city council and became mayor for the third time.
characteristics and the issues related to them will be developed in detail in the following chapters.

The case studies clearly reflect how similar types of transit plans and proposals come about from different motivating factors. In Boston, a rapidly growing area, the main motivating factor was the fear of congestion on a corridor with no fixed-guideway transit facilities, in light of a major highway reconstruction. The elected officials from that area quickly fueled the possibility of revitalizing an abandoned commuter rail network traversing their constituencies' districts. In Santa Clara County, also a growing area, the motivating factor was an attempt to gain control over land development, through the redirection of urban sprawl towards higher density patterns and the revitalization of the downtown area. The fact that such a vanguard area, the forefront of the world's computer technology, did not have a visible transit system also stimulated the political arena in support of the construction of an LRT system. In Buffalo, a distressed area, the main motivating factor was the need to turn around a declining economy and, in that attempt, to revitalize its downtown core. The perceived competition from nearby urban areas -- mainly the Canadian city of Toronto -- further funneled the interests for a fixed-guideway system. In Madrid, old plans developed at times of economic expansion created a need to improve the overall performance of the rail network through additional investments. Other motivating factors included political ones and the perception that only with investments in the subway network the declining trend in ridership could be reversed. Finally, in La Paz, the motivations were mainly political coupled with a complete lack of
a permanent rapid transit system in the city. 154

Once they come about, transit plans and proposals easily become an end in themselves with very little time or willingness left to reflect on their real desirability. This situation translates into an attempt to diminish the potential impacts -- for instance, in terms of capital and operating costs -- of the initially preferred alternative and ends up putting the technical agenda behind the political agenda, affecting how the technical study is accomplished. This characteristic is illustrated by the fact that in none of the case studies did the preconceived ideas about which project to pursue change substantially along the lengthy analysis process since the formation of the initial proposals (except for the scaling down of the Buffalo rail system from heavy rail to light rail rapid standards).

The permanence of fixed-guideway systems and the life-long impacts they create once they are constructed 155 contributed to the steadiness of the support for their implementation. This type of system can help build a strong and committed constituency willing to fight for or against the system. Once this constituency is mobilized, the political stimulus becomes intense and even oppressive 156. The political agenda then goes

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154 In all the cases as well there was an implicit intent to put in place systems that could serve as the trunks of expanded multi-modal services. This goal can be better achieved, due to their permanence, through the construction of rail networks rather than other systems.

155 This is related to what Henry [1974] calls the 'irreversibility effect'. This effect is an important consideration for investment decisions under uncertainty.

156 In all the cases, the survival of the proposals in spite of setbacks, and the development of constituency support, required leadership, or an individual, individuals, or coalition of individuals, probably political actors, who were willing to persist on moving the project forward. These individuals are what Bardach [1977] calls "fixers" of the implementation game. The problem, Bardach mentions, is that too
ahead of the analysis process, monitoring it very closely and preparing it to support its predefined desired outcomes. As indicated in section 2.3, the uncertainty of both cost and demand estimates at the time of project planning further allows the decision-making political agenda to take control of the process.

Cost estimates along with demand estimates, because of their uncertainty, constitute one of the workhorses of the analysis process. The output of the cost estimation process is paramount for the political acceptability of the project -- in addition, of course, to its financial feasibility. Capital and operating costs must stay at reasonable levels. But an effort to keep costs down, by ignoring or scaling down some elements of the system, would most likely turn into cost overruns once the system is constructed. As the U.S. case studies illustrate, the reasons for cost growth are mainly due to scope changes after taking into account the effects of inflation. Sometimes the growth in costs comes from the accidental or deliberate ignorance of who -- or which institution -- is in charge of paying for the costs of particular items. In the case of Buffalo, the NFTA believed that a New York State law required privately owned utility companies to bear the expense of relocating their lines when their paths conflicted with proposed public improvements. The affected utility companies pursued the matter through the federal and New York State courts and, later, the state supreme court ruled that the utility companies

few fixers are able to know where, when, how, and about what to persist effectively. The lack of a fixer seems to be one of the major reasons for the setbacks in the planning of an LRT system in Denver, Colorado. In the case of La Paz, the assistant to the mayor acted as fixer but did not have the skills to put the project forward in an effective manner.
were to be reimbursed for removal, relocation, and/or support and maintenance of their lines. A similar instance occurred in the case of Santa Clara as the transit agency had to add the costs of upgrading the trackbed of the downtown section of the LRT system (from ballast to concrete) because the city of San Jose refused to take that responsibility.

In terms of the technical process itself, the size of the projects that are the subject of this thesis requires a substantial amount of data, hardware (i.e., tools to process, maintain, and manipulate the data), and expertise (i.e., knowledge of accounting strategies, operations planning, and experience). For capital costs, the main task consists of figuring out precisely what items need to be included and, simultaneously, what items are the least reliable. But in all the case studies, analysts indicated that the most difficult task was the calculation of operating costs. The calculation of these costs requires the consideration not only of the operating strategies for the proposed system but also of the changes the introduction of the new system will generate in the existing transportation network.

In the calculation of both types of costs, a major issue consists of maintaining the data and updating them as changes take place along the process. The Boston case study, as well as that of La Paz, attempted to tackle this issue through the use of then available computer technology -- mainly, microcomputers. In no case, however, a reliable and somewhat powerful computer-based information system was in place, either because the technology was not available or not known at the moment or because of the

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157 In response to the ruling, UMTA awarded NFTA a separate grant for utilities relocation in addition to the funds specified in the full funding contract.
perception that the temporal nature of the specific project planning exercise, with very low chances of being replicated in a future situation, did not merit the implementation of such a system.

In all the cases, the expertise needed in the technical process required the hiring of outside analysts -- i.e., not part of the decision-makers' organization -- to carry out the technical process and "advise" decision makers. This situation generates a two-way relationship where each party needs the other. The decision maker needs the analyst to perform the technical analysis to support the final decision; the analyst needs the decision maker to have projects to work on. This relationship induces a partnership whereby the analyst tries to please the client -- i.e., the decision maker -- so that he or she may have a good chance of getting additional projects. The need the decision maker has for the analyst gives the latter some leverage to attempt to be more effective in trying to direct the political agenda or, at least, not to be left behind it. This situation however depends on the mobility of the political agenda itself and, as the U.S. case studies illustrate, hardly occurs. In the La Paz case, there was an attempt to redirect the process, but once again when the analysts made this attempt the political agenda was at a much more advanced stage -- in terms of spelling out preferences -- and its redirection became very difficult. ¹⁵⁸

Another relationship emerges out of the need for outside funds to construct the preconceived transit proposal. The presence of the higher institution -- e.g., the federal government in the U.S. -- and its

¹⁵⁸ For a fuller account of this relationship see Szanton [1981] or Benveniste [1972].
financial powers generates the need for a planning study that "justifies" the transit proposal. In this relationship, between the funding institution and the decision maker's organization, another game takes place, with each one trying to influence the other's opinion about the design and desirability of the project. Other actors, such as the analyst or the affected constituencies, will try to interfere in this relationship in an attempt to make their particular opinions heard.

In the case studies, the development of the planning process (with the decision makers' continuous support for a single alternative since the conception of the preliminary ideas) seems to suggest that decision makers, although fully aware of the importance of the technical process to put the project forward, did not believe that the technical studies could influence the final decision about which transportation alternative to pursue. If not explicit, this statement was reflected by the events and by decision makers' lack of knowledge of the general technical issues, controversial values, etc. involved in the analysis process or their statements about the merits of their preferred alternative. Another indication is the frequent complaints about the technical process itself (in particular, in the U.S., about the Alternatives Analysis process).

Decision makers also stated that if they had not been able to secure the funds to construct the project from the higher level institutions, the transit project would probably not have been built. This belief indicates that decision makers had a major interest in obtaining the funds needed for the construction of the particular transit project and that they perceived the technical analysis mostly as a requirement to secure those funds. In the U.S., three main reasons were cited for the need of the analysis
process: (a) to satisfy Federal and state environmental laws; (b) to get
the necessary funding from federal and state agencies; and (c) to assist
the community in arriving at a consensus.

3.5. Summary and Conclusions

This chapter has included a description of the case studies along with
some comments on the main issues raised in the presentation of each
particular case study. In addition, three major set of characteristics
have been identified as common themes of reference in the case studies: (a)
the technical, (b) the decision-related, and (c) those that affect the
interaction between analysis and decision. Within the technical set, three
characteristics were highlighted: (1) the sources of rises in capital and
operating costs; (2) the special features of fixed-guideway systems
(mainly, their permanence) and the implications of these features on the
development of the project and the support for it by the affected
constituencies; and (3) the requirements of the technical process. Within
the decision-related set, three other characteristics were identified: (1)
the explicit or implicit motivations for proposing the system; (2) the
local versus central government contentions about the viability of the
transportation projects and the reflection of these contentions on cost
estimates; and (3) the constraints and requirements on the decision-making
process. Finally, as to the relationship between analysis and decision,
three major characteristics were recognized: (1) the relationship between
analysts and decision makers, and between funding institutions and decision
makers; (2) the force of optimistic expectations on the analysis process;
and (3) the different interpretations of the intent of alternatives
analysis requirements, and the perception of decision makers about the role of the technical process. The next two chapters discuss at greater length the first two set of characteristics as part of both the analysis and the decision-making processes. The third set of characteristics is developed in chapter 6 as the two processes are brought together and the analytical framework is developed. The issue of the role of technical analysis is further discussed in the chapter 7.

These characteristics support the use of the theoretical framework highlighted at the end of chapter 2. They illustrate the difficulties of achieving optimality from a rationalistic perspective; they portray the different actors attempting to gain control of the process; and they illustrate how the process unfolds as a struggle over ideas with a strategic purpose generated by the political environment surrounding the planning process. Stone [1988] refers to similar conclusions in her discussion of how problems are defined in the policy process:

"(...) [P]roblem definition is never simply a matter of defining goals and measuring our distance from them. It is rather the strategic representation of situations. Problem definition is a matter of representation because there is not objective description of a situation; there can only be portrayals of people’s experiences and interpretations. Problem definition is strategic because groups, individuals, and government agencies deliberately and consciously design portrayals so as to promote their favored course of action. (....) Representations of a problem are therefore constructed to win the most people to one’s side and the most leverage over one’s opponents."

The argumentative approach helps develop a framework for the cost-estimating process and identify those components that prevent the rationality of the process and the achievement of the intended results (the ones advanced by the normative rational framework). The argumentative

159 Stone [1988], p. 106.
approach also helps explain how decision makers' perceptions about the role of the technical process coupled with their relationships with analysts influences the technical process and why some deviations from the expected outcomes take place.
4. THE TECHNICAL PROCESS OF ESTIMATING COSTS

4.1. Introduction

This chapter discusses the technical process of cost estimating within the context of analyzing and comparing transit alternatives. The main components of this process are data and methods. Data are the values for the different variables used as input to the methods; methods are the ensemble of equations used to represent the relationship among the different variables. The methods reflect the assumptions adopted to imitate as closely as possible what has happened, happens, or will happen in the real world as it concerns the monetary disbursements needed for covering the capital and operating costs of the project. These methods may be readily available (e.g., the calculation of the present value of a stream of costs) or may need to be created by the estimator for the particular situation under analysis (e.g., the calculation of the operating costs may happen to be particular to the project under study, and as such may require some empirical research and equation development).

The technical literature stresses that a good cost estimate is a necessary input to informed management decisions. This literature emphasizes the importance of a sound information basis for estimating costs. This basis consists of two major elements: the quantities of the components that will constitute the transportation system, and the unit prices for those quantities. Other components that are equally important are those that affect the ultimate results of the estimating method such as the length of construction, the inflation rate, and the financing

\[160\] Clark and Lorenzoni [1985]; Stewart [1982]; Calder [1976].
The subject upon which the cost-estimating process is discussed in this thesis is a public transportation project. The planning of these projects requires great skill and care in estimating -- in particular capital and operating costs -- because of the presence of unknowns that are difficult to foresee at the time of carrying out the planning process. The size of the project activity, the need for multiple skills, and the span of time usually required for its design and construction, result in the need for precise planning, scheduling, estimating, and management. In many cases, as in the ones discussed in this thesis, the need for technical expertise forces the transportation operators and decision makers to contract out the conduct of such studies. This conduct may fall in the hands of several outside consultants, with different phases or components of the study assigned to different consultants.

Most of the literature on cost estimating focuses on processes taking place within the private sector context. Within this context, a major consideration is the importance of making profits. This framework differs markedly from that for the public sector where the objective of a project may be to gain support for other projects or simply to generate political gains for an elected official. As indicated in section 3.4, the case studies clearly reflected how similar types of transit plans were generated with very different objectives in the mind of their proponents.

The private sector framework helps private management understand clearly the function and meaning of cost estimating. In the public sector, however, that function is more diffuse and vague, and sometimes constitutes a way to support previously made decisions rather than a way to help
decision making. Furthermore, as the institutional framework of the case studies illustrated, many public-sector projects are very complex in terms of the number of actors involved or the impacts they may have. This complexity makes it more difficult than it is in the private context to identify the decision maker(s) or the quantities the decision should try to maximize (i.e., the goals to be achieved). (More differences between public and private sector projects, as they relate to the decision making process, are discussed in chapter 5.)

4.2. Cost Estimating: Approaches and General Issues

An estimate is a judgment, opinion, or forecast of a future work or activity. A project cost estimate, therefore, is a judgment or opinion of the cost of that project; it is a forecast of what the accomplishment of the works and activities needed for carrying out that project will cost, in monetary terms.

Quantities and unit prices are the two essential ingredients of a cost estimate. The calculation of the quantities is accomplished by using an estimating method, whereas the calculation of the unit price to be applied to the quantities is determined through the gathering and analyzing of data. An estimating method is a systematic and consistent approach to predicting or estimating the cost and schedule for the execution of the works and activities needed to carry out the project. For each item, whether it be equipment, bulk materials, labor, or engineering, a method must be developed. The degree of sophistication applied to the estimating method must be balanced by the estimating process needs, and will be limited by the organizational capabilities of the institution in charge of
performing the cost estimate. Cost estimating methods can be developed "in-house" or be taken from similar exercises performed in the planning of other public transportation systems.

4.2.1. Approaches to Cost Estimating

The two general approaches to estimating either capital or operating costs are the "top-down" or parametric approach, and the "ground-up" or industrial-engineering approach. The parametric approach uses historical data from previous projects and extrapolates the cost of new project based on increase or decrease quantity, size, weight, power level, or other factors for that new project. The industrial-engineering approach requires the estimating of man-hours and materials of each element and sub-element of the project, and the pricing and accumulation of all the costs of the elements and sub-elements into a total cost estimate. Both methods of estimating are satisfactory for various phases of the estimating cycle. For instance, at the time of a feasibility study -- such as in the case of La Paz --, an estimate based on the parametric approach may prove satisfactory; on the other hand, for a more advanced stage of the planning process, a "ground-up" estimate would be more appropriate. The parametric and the industrial-engineering approaches become more closely related as the estimating function deals with more specific and itemized project components.

There is no clear-cut rule as to which method of cost estimating is the best, although it would probably be possible to indicate which approach is preferable for a particular situation. The top-down parametric estimate, used alone, has limitations from the standpoint of visibility of estimate
components, identification of major cost drivers, isolation of inflation effects on each cost element, and adjustment of costs to reflect subtle changes in the project scope. At the time of project planning, some of these purposes may not be deemed of major importance, and hence a top-down approach may be adequate. Furthermore, one or the other approach may better serve the purposes of the decision-making process in terms of, for instance, claiming which alternative is the best and advancing the planning stage into preliminary engineering and construction. The approach used to estimate the costs depends then on the intended final use of the estimate and the need for an accurate overall total versus the need for details (for instance, for control purposes). It will also depend on the estimating tools available, the time available to prepare the estimate, the money available for preparing the estimate, and the amount of previous historical cost data available.

In the case of Buffalo, initial (1976) studies were conducted under time constraints. The detail with which some cost estimates were carried out differed from one alternative to another (e.g., more detailed for those for which some preliminary work had been done, like the heavy-rail alternative). In fact, some estimates, in particular those of the later-selected LRRT alternative, were calculated on the basis of extrapolating cost estimates from other alternatives. Subsequent decisions, however, took the preliminary estimates for all the alternatives as having an equal footing and did not attempt to account for the higher uncertainty involved in the capital and operating cost values of the extrapolated alternatives, among them the selected LRRT system.

Clark and Lorenzoni [1985].
In the Boston case, the technical process followed an approach closer to the ground-up methodology because of federal requirements and the more advanced stage of analysis. Federal requirements try to improve the accountability of the estimates by requesting a larger specificity in the cost components. This ground-up approach, however, was rated as too demanding by the analysts in charge of applying it. They indicated that large amounts of time had to be spent on gathering information and that the approach did not allow for the dynamism required by the planning process.

In the case of La Paz, time, money, and data constraints, in addition to the general institutional and political environment, dictated the method to be followed, with most estimates based on past transit projects in other cities all over the world. It was also a study done at an early stage of analysis, where the attempt mainly focused on screening a set of six major alternatives. The method followed a top-down approach with cost data based on bidding documents and information gathered from similar systems in other parts of the world. In the case of Madrid, with a strong political component as well, the analysts also followed a top-down approach based on aggregate information from other parts of the subway network.

Very little standardization in estimating procedures has occurred to date because of the competitive and bargaining nature of the cost estimating process itself, as well as the different requirements of the decision-making and institutional processes. In the case of Madrid, neither the transportation operator nor the central government were interested in more than a top-down approach. The approach suited the needs of the central budgetary process, and left room for negotiations in reallocating funds from one component of the project to another. In La
Paz, the dynamics of the political process, with a very unstructured nature and a biased perspective on the project, clearly favored a top-down approach.

In the U.S., the federal-government attempt to boost the accountability of the projects that it partially funds and, in addition, made it harder to complete the necessary requirements for the approval of transit capital projects (in an effort to minimize demands on UMTA formula and discretionary funds and, indirectly, reduce the size of the federal deficit), has increasingly moved the costing approach closer to a ground-up approach. The Boston case was one of the first attempts at standardizing the cost-estimating process (among other components of the overall planning process). However, in this case, the attempt did not get too far because of the difficulties of applying such an approach at the planning stage of analysis, not only because of the uncertainty about cost values but also because of the perspectives and expectations decision makers and analysts had about the technical analysis. Because of this, some elements of the estimating process closely followed the federal guidelines; other elements (or alternatives) did not. Hence, the characteristics of the planning process and the conditions surrounding it, that change from one situation to another, do not allow for easy standardization.

In any situation, the approach selected indicates some assumptions about the investment. For example, by adopting a top-down approach the estimators assume that the investment will behave similarly to the previous works and projects upon which the values are taken (the cases of Buffalo, with the extrapolation of cost values for some alternatives, and La Paz, with cost estimates taken from similar systems in other parts of the world,
illustrate these assumptions). In addition, different approaches support certain functions better than others. For instance, for control purposes in subsequent stages during final design and implementation, the ground-up approach has obvious advantages over the top-down approach. However, during the planning stage, this function is relegated to a second stage since it does not present a major priority for decision makers (vis-a-vis, for example, the decision to select one among several alternatives or the need to comply with a set of bureaucratic rules). In this situation, therefore, the need for a ground-up approach is largely diminished.

Furthermore, the estimation is made on certain assumptions about the scope and schedule of the project. If these assumptions are not kept, because for instance monitoring the implementation of the project cannot be (or is not) performed adequately, they are not likely to produce an accurate estimate. In other words, if monitoring is lousy, estimates will very likely be faulty. This type of assumptions and their breakdowns were present in most of the case studies. In fact, as was illustrated in the cases of Santa Clara County (underpass for railroad line, highway standards, etc.) and Buffalo (La Salle Street station, underground utilities, etc.), the largest proportion of cost increases come from the failure to keep the assumptions made during the estimating process into the subsequent design and implementation stages.

Approaches, perspectives, assumptions, and functions are intertwined and affect how the cost-estimating process is undertaken and how we ultimately perceive the accuracy of the technical process. This intertwining suggests that depending upon which perspectives or functions are prevalent at the moment, assumptions and approaches should be adapted
Accordingly.

Either of the two general approaches to cost estimating can be complicated if different construction schedules are considered, that is, if the possibility of starting the alternatives at different times or in different stages are incorporated in the analysis (or if different financial mechanisms are evaluated). The possibility of phasing the transit investment is rarely considered for four main reasons: (a) it would increase considerably the number of alternatives to compare (and the computational requirements to perform in the estimating process), (b) the total costs would probably be higher as the economies of scale associated with a single large project would be lost, (c) the consideration of the project as a single package would assure, if approved, its complete construction, otherwise some parts of the project may stay unbuilt, and (d) the demands over the decision-making process and local institutions to follow the project over a much longer period of time are more compelling and require more persistence.

However, the elimination of these possibilities, in an attempt to speed up the process and gain approval for a total project, misses the point that by phasing the investment the annual disbursements would be lower and, although the final costs may be higher, the likelihood of getting quick approval for smaller incremental parts would be greater (as showed in the Boston case study). The incremental approach does not, by any means, assure the "tidiness" of the proposals as it may induce to request funds for segmented proposals that are inoperative by themselves and require additional segments, and the subsequent additional funds, to achieve their full potential. Therefore, segmented alternatives are worth full
consideration in the analysis process, although they may not end up being the most adequate alternative from an operating strategy or financial standpoint.

Interestingly enough, as the U.S. case studies illustrate, the final decision about which system to pursue usually includes only a portion of the initially-desired project. In spite of the fact that an incremental-investment approach is not usually considered in the analytic process, this approach often turns out to be the one that results from the negotiation process between the higher-level institutions and the transportation agency. For instance, in the case of Buffalo, the possibility of phasing of alternatives deserved some discussion but it was never carried out very far. However, the alternative ultimately constructed resembled a first stage (6.4 miles) of the initial attempt to construct a larger network of 20 miles or a more limited one of 11 miles.

In some cases, the explicit indication of the phasing of the system is not possible due to political considerations. In the case of Boston, the project called for the investigation of seven alternatives, four of them involving commuter rail. The implicitly preferred alternative included three commuter rail lines terminating in Boston’s South Station, a centrally located major rail station. The federal government initially required the study of the complete alternative, and its comparison to the other alternatives, because they believed the full system would be the only one that could justify the investment.\(^{162}\) As the cost of the system grew

\(^{162}\) If the system did not reach the centrally-located station, the federal government and local groups thought that not as many people would use the system, because transfers would decrease the quality of service. This decrease would reduce the cost effectiveness of the system, and the required thresholds could not be reached.
from $200 million to almost $400 million, the federal government started mentioning the possibility of phasing the investment mainly because funds available for that particular type of projects were not in good supply at the moment. In addition, the fact that some communities were protesting against commuter trains passing through their jurisdictions, changed the perceived support for the entire project and caused local transit officials and the federal government to support the scaling down of the commuter system, by starting with a reduced system (the one including the least controversial and the least expensive lines) and continuing with the other lines as knowledge of all the impacts improved. The reaction of the supporters of the restoration of commuter service was tremendous, and the governor quickly indicated that the full system would be constructed, and successfully persuaded the state legislature to approve a bond issue to pay for the local share of the total system (at the moment, almost $200 million). The draft environmental study, then, did not include the possibility of phasing the investment, although this possibility was still in the minds of the consultants and transit officials.

**4.2.2. Cost Classifications**

Since the quantities of the different items required for the construction of the transit project are one of the two major elements of a good basis for cost estimating, an adequate process must be established to account for all the cost items and to avoid any double counting. But this effort may be futile if, in both the top-down and ground-up approaches, no attempt is made to distinguish between types of costs so that the visibility of what changes with what can be easily perceived.
Costs can be classified according to different criteria. One of most widely-used criteria consists of dividing costs depending on how directly they are attributable to the specific work activity or work output being estimated. For capital costs, we have: (a) direct costs or those associated with the materials and labor involved in the construction of the project; and (b) indirect costs, or costs of items that do not become a part of, but are necessary costs involved in, the design and construction of the project. These indirect costs comprise engineering costs, contractors' fees, field labor overhead (which includes temporary construction facilities, field supervision, construction tools, and labor payroll burden), and miscellaneous costs such as insurance, freight, and duties and taxes. For operating costs, direct costs include labor -- operators and maintenance crews -- wages, energy -- fuel and electricity -- costs, maintenance parts, and ticketing and fare collection costs and indirect costs include administration and scheduling of transportation and maintenance operations, system security, and insurance.

Other classifications are also possible. Depending on how they change along the life of the project, costs can be divided into fixed costs, or costs involved in an on-going activity whose total cost will remain relatively constant regardless of the ridership on the transit system or the phase of the demand cycle being estimated (e.g., peak or off-peak periods), and variable costs, or costs that vary in relationship to the demand on the system. Of course, fixed costs are meaningful only if they are considered during a given period of time, since inflation and

\[163\] Clark and Lorenzoni [1985].
escalation will always provide a variable element to the "fixed" costs \(^{164}\).

These classifications are useful for the purposes of relating capital and operating costs with other elements of the analysis, namely the demand calculation and the financial appraisal, and account for the uncertainty of estimates and improve the transparency of the cost estimating process. On the demand side, there are elements of a project that do not change with the level of demand (at least for a wide range of demand values). For instance, the cost of stations, tracks, poles, or signalization, does not change for a range of demand values. On the other hand, the cost of rolling stock equipment and some elements included under operating costs depend on the ridership level, and as such their accuracy would be affected by the accuracy of the demand estimates. Table 4.1 shows the classification of major operating costs in fixed and variable, depending on how they change with demand.

The investigation of the case studies indicated that this type of cost classifications is hardly used, at least with the purpose of realizing how much changes in output -- i.e., demand -- would affect costs. In the U.S. cases, the accountability concern -- i.e., every single item must be listed and included -- thwarted the possibilities of relating cost items to demand and, therefore, did not allow for quick sensitivity analyses based on demand. In the case of Madrid, the evaluation was carried out on the basis of which value of travel time would justify the investment, and no attempt was made at perceiving how positive or negative changes in demand would affect costs (and consequently the cost-effectiveness, however measured, of the project).

\(^{164}\) Stewart [1982].
Table 4.1  Operating Costs Classification

<table>
<thead>
<tr>
<th>Category</th>
<th>Type</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>fixed</td>
<td>administration and scheduling of transportation operations; ticketing and fare collection.</td>
</tr>
<tr>
<td></td>
<td>variable</td>
<td>operator wages and fringes; fuel and lube; tires and tubes.</td>
</tr>
<tr>
<td>Equipment</td>
<td>fixed</td>
<td>maintenance administration for vehicles; maintenance of fare collection and counting equipment.</td>
</tr>
<tr>
<td></td>
<td>variable</td>
<td>servicing revenue vehicles; inspection, maintenance, and repairs of vehicles.</td>
</tr>
<tr>
<td>Way and structures</td>
<td>fixed</td>
<td>maintenance administration for facilities; maintenance of roadway, track, and structures; maintenance of signals, communications, and control facilities; maintenance and repairs of buildings, grounds, and equipment; maintenance of passengers stations; operation and maintenance of electrical power facilities.</td>
</tr>
<tr>
<td>General and</td>
<td>fixed</td>
<td>systems security; injuries and damages; general insurance; other general administration.</td>
</tr>
<tr>
<td>administrative</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: the distinction between fixed and variable refers to which costs would change with a medium change in ridership (e.g., increase or decrease of 15%).

In the La Paz case, by contrast, variable costs were directly related to demand and sensitivity analysis were performed for different values of demand. In that case, the explicit recognition of different types of costs, in addition to improving the transparency of the process, helped cope with uncertainty and the problems of escalation (changes in scope).

The variation of demand, however, was not related to changes in the fare level -- i.e., demand was considered fully inelastic.
The classification of costs also helped structure the estimation process and make analysts and decision makers realize how decisions may change with potential changes in the assumptions of the transit project.

More frequently, costs are categorized according to the other classification criterion: how directly they relate to the construction or operation of the transportation facility (i.e., direct and indirect costs). This type of classification plays a major role during final design and construction for the purposes of allocating costs to particular activities with a view toward procurement and work contracting. However, during the planning stage, the direct-indirect classification does not help reduce the uncertainty of the estimates and elucidate the tradeoffs among transit alternatives in the light of that uncertainty. In this sense, the demand-based classification can better serve the needs of the decision-making process. Furthermore, the demand-based classification could be used to assign financial responsibilities to the institutions involved in the funding of the project. By assigning items to particular institutions based on how responsive to demand the costs of those items are, a better internalization of the funding consequences of the project would be incorporated into the process. For instance, if a local institution is in charge of paying for items whose costs vary with demand, an effort would be made at the local level to estimate as accurately and unbiasedly as possible those costs and the demand for the system and see what the consequences would be if the estimated demand is not realized or surpassed.

4.2.3. Computerized Estimation: Database Management Issues

In addition to the quantities, the other element of the cost
estimating basis is unit prices. This information is gathered through surveys, quotations, historical background, comparable systems, and the like. Together, quantities and unit prices encompass an enormous amount of information that must be organized and managed so that it can be kept up-to-date during the planning process. In addition, the cost estimating process involves the use of this large amount of information for fairly repetitive tasks. These two characteristics make the process particularly suitable for the use of computer-based technology. Moreover, the developments in both hardware and software computer technology during the last ten years, has improved the possibility of making this technology easily available to any estimating process. In addition, the automation of the cost estimation process presents some interesting benefits in terms of speed, consistency, fewer unintended errors, neater presentation, and improved communications.

The theory of the application of computer technology contains the fields of management of information systems (MIS) and decision support systems (DSS)\(^{166}\). The first field discusses the organization, processing, retrieval, and update of the data needed for cost estimation. The second field covers the manipulation of the data for the purposes of cost analysis and the performance of sensitivity analyses. In general, the management of information includes all the steps from gathering the data, to analyzing it, to the application of the estimating unit data, to the generation of final cost reports. For the purposes of cost estimating, the major thrust behind these concepts falls not so much on how to organize the relevant

\(^{166}\) Gorry and Scott Morton [1986]; Senn [1984]; Ahituv and Neumann [1982]; Keen and Scott Morton [1978].
information, but rather on figuring out what it means and what relevance it has to the decision at hand. Decision support systems are MISs that also have some processing capability designed to help the decision maker use the information ("what if" analysis) to perceive the tradeoffs between different courses of action.

The automation process involves several important issues. First, cost programs must be developed or purchased. Buying a program makes it available for use sooner, enables the user to use the experience of others and, overall, costs less. On the other hand, the program purchased may not meet the needs of the estimator and it may be difficult to verify the quality of the program. Furthermore, it may be difficult to revise.

Second, the organization in charge of managing the computer-based information system must have the technical and organizational capabilities to develop and maintain the data collection or data management system. Methods would be ineffective in producing reliable estimates if good unit-cost data to convert quantities to costs are lacking. In addition, most cost data are dynamic and subject to almost instant obsolescence and a data management system is required to keep data current. The task of the cost estimator in setting up such a system is further complicated by the massive amount of the data that must be accumulated and managed.

These issues reflect the fact that the cost estimation process is just as valuable, if not more so, than the cost estimate itself. Often a cost is quoted without qualifications related to the conditions on which the estimate is based. This is one reason for frequent misunderstandings and confusion concerning the costs of an activity. For instance, the case of
Buffalo has become known for large cost overruns\textsuperscript{167}. However, when inflation is taken into account the increase in initial estimated costs is not more dramatic than in other less publicized cases (see table 1.1). A different criticism (voice by some individuals interviewed) targets the low number of miles Buffalo's LRRT system covers considering the amount of money invested, but this is a much more subjective and controversial assessment. In Boston, the near doubling of the initial estimates (from $200 to almost $400) was mostly due to the lack of consideration of some items in the first estimates (such as land acquisition costs and provisions for design, administration, and contingencies) and the different years of comparison (the feasibility study was based on 1984 dollars, the alternatives analysis was based on 1986 dollars\textsuperscript{168}). After accounting for "missing" elements and inflation, the two estimates were much more similar, a fact that was unknown to some of the key detractors of the system. These arguments are examples of the consequences of the lack of qualifying cost estimates. (Of course, these situations also come about as some actors use cost figures for strategic purposes. However, this is a different issue that will be discussed in chapters 5 and 7.)

Whenever a cost of an item, whether it is a process, product, or service, is quoted, it should be accompanied by qualifying information including: (1) a full description of the item; (2) the date for the cost of item (or key milestones for an activity); and (3) how the item relates to output (demand). Depending the stage of analysis and the resources

\textsuperscript{167} General Accounting Office [1986b].

\textsuperscript{168} This is an assumption of the author, since it was impossible to find a consensus about which year the cost estimates of the alternatives analysis were based on.
available to carrying out the cost estimating function, the qualification could also include (4) the geographical location of the item or activity; (5) the skills and organizations assumed available to perform the work to complete the item or activity; (6) the expected quality and service life of the output related to the item. This structure parallels the one that in construction management is called a work element structure (sometimes also called a work breakdown structure)\textsuperscript{169}. The structure serves, in addition, as a framework for collecting, accumulating, organizing, and computing the direct costs of a work activity or work output\textsuperscript{170}.

This information structure can be organized within a computer-based framework that allows for easy editing and updating when changes occur in the planning process. The implementation of database relational systems\textsuperscript{171} would further improve the possibilities of relating cost items to other variables, such as demand, that affect the quantity levels that enter the cost estimating methods for the purposes advanced in section 4.2.2.

In the case of La Paz, the analysts developed a spreadsheet-based system where costs were connected to demand, quantities (level of investment), and unit prices. The system, although at a feasibility level

\textsuperscript{169} Stewart [1982].

\textsuperscript{170} A work element structure is developed by subdividing a process, product, project, or service into its major work elements, then breaking the major work elements into subelements, and subelements into sub-subelements, and so on. This framework assumes a hierarchical relationship among the elements: the resources or content of each work element are made up of the sum of the resources or content of elements below it. The major subdivisions can be either functional or physical elements. The second level usually consists of a combination of functional or physical elements if a product or project is being estimated.

\textsuperscript{171} Date [1986]; Salzberg [1986]; Smith [1985].
of aggregation, allowed flexibility in the process and the performance of a variety of sensitivity analyses. Its characteristics granted a generous amount of time to argumentation based on quick revisions of the model's input values or assumptions.

In the case of Boston, the amount of data involved was much larger. The spreadsheet-based system was built in a modular fashion and did not attempt a full relation to variables that affected the level of investment. The system did not allow for easy sensitivity analyses. This was reflected in some mistakes that appeared in the capital cost figures. For instance, the first attempt to calculate capital costs included for each alternative a low, a medium (the best estimate), and a high value for each one of the cost items. For one of the alternatives, the upper bound (or high value) of one of the items (contingencies) was lower than both the lower bound and the best estimate, given an overall total for the upper bound only slightly larger than the middle value (or best estimate). This error appeared in several reports during the planning process, including the one submitted to the federal government for approval -- the Draft Environmental Impact Statement.

The importance of these issues are not so much in the computerization per se but in what they mean in terms of organizing the technical process, allowing flexibility in the planning process, and a more effective interaction -- however futile if may turn out to be -- with the decision-making process (effective in terms of quick response to changes and requests from the decision-making process). The computer-based framework, by specifying which items to consider and the relationship among them and other input variables, can also help structure the thinking, learning, and
argumentation processes.

Although the many particularities of any transit project does not permit the easy implementation of a standard cost-estimating information system, the considerable amount of time spent gathering cost information could be reduced with the implementation of a management information system to help keep track of major unit-cost components. In the U.S., this "centralized" approach was supported by UMTA but rejected by the local analysts on the basis that projects are too specific to merit some unified central database. Although, the scope of this topic falls outside the extent of this thesis, considerable room exists for the careful consideration of the implementation of a databank that would allow transit planners to obtain unit cost information for the quick purpose of estimating the costs of any proposal. This approach would not directly and substantially reduce the cost underestimation problem (as the case studies illustrated by showing that unit cost information is not the major reason for cost underestimation) but would shorten the time to perform some of the components of the technical process and would help carry forward some of the other proposals advanced in the framework presented in this thesis (e.g., sensitivity analyses, criteria argumentation, etc.).

172 The Highway Design and Maintenance Model (HDM) is an example of a computer-based program that allows the user to calculate the costs of several road-maintenance alternatives based on some pre-specified relationships and after the introduction of specific unit-cost information. This program is being put forward by the World Bank in spite of the fact that conditions in developing countries vary markedly. However, HDM is an effective tool in structuring the road-maintenance process. At the same time, HDM is flexible enough to allow for the incorporation of different assumptions and the performance of calibrations as needed. It is also a good example of a cost-estimating tool that reduces substantially the time to generate cost estimates for road-maintenance alternatives. (The World Bank [1988].)
4.3. Cost Estimation in Transit Project Planning

In the process of analyzing alternatives, an important issue is the level of effort and detail that must be spent on developing cost estimates. Theoretically, the level of effort and detail invested in estimating capital and operating costs should be that necessary to ensure that the choice of an alternative does not change with additional cost information. Analysis then would be extended to the point that additional information will eliminate the chances that the decision will be changed (i.e., the expected value of additional information is zero). In other words, since the final outcome of the alternatives analysis process is the selection of the "best" alternative, the technical process should be carried out to the point that the "benefit of the marginal knowledge" would be zero, that is, to the point at which knowing more about the estimates would not improve the effectiveness of the selection of the "best" alternative. This is, obviously, a theoretical reasoning but sets the stage for more practical discussion.

In practical terms, two levels of estimating effort can be defined: one, following the parametric approach, for "typical" facilities, and the other, much more detailed, following the industrial engineering approach, for "special" situations. The first level can be applied to those segments that consist of a "typical cross-section" (e.g., track sections) or for a "typical facility" (e.g., station). Detailed units costs are used with quantities taken from the typical sections to derive costs per lineal foot for each section or per type of facility. Costs can then be computed

173 Ryan, et. al. [1986].
to represent the capital cost of each identified typical section or facility, exclusive of systemwide elements and add-on items. The special situations consists of those segments or structure that do not present "typical" characteristics (e.g., major structures or track sections on difficult terrain). These special elements should be computed following the "ground-up" approach, in detail, with drawings, detailed quantities, and detailed unit costs.

Systemwide elements include those items of capital investment that cannot be defined on a segment-by-segment basis (e.g., vehicles, electrification). They must be calculated with units costs applied to systemwide quantities. Some of these systemwide elements are related to operating costs that, in turn, depend on patronage levels and, hence, on the results generated in the demand models. Add-on items consist of contingency allowances and the costs of engineering and construction management services. The costs of these items are usually calculated as percentages of the estimated baseline capital costs (depending on how detailed the calculation of these costs has been).

The estimation of operating costs is more controversial because their calculation depends to a great extent upon the estimation of other similarly controversial variables: service and patronage levels. (As was mentioned before, some capital costs do also depend on patronage levels but not to the extent that operating costs do. In particular, this is the case with rolling stock equipment.) Furthermore, the costs should be calculated to optimize the performance of the system to provide the expected service and patronage levels. This process involves the analysis of the transit network, demand estimation, and the balancing of transit supply with
transit demand. Once the operating statistics are obtained (e.g., vehicle-miles, vehicle-hours, peak vehicles, etc.), the pertinent cost models can be applied. The development of these models usually require the application of some regression analysis with a calibration procedure to adapt the parameters to the particular situation of the city where the transit system is being planned. To the greatest extent possible, the calibration should be done using "typical" conditions (e.g., no significant changes in service levels, labor productivity, or ridership patterns). Furthermore, service characteristics should be similar to the ones proposed for the system being planned.

Summarizing, the prevalent approach to cost estimating in transit project planning is a combination of both the parametric and the industrial engineering approaches:

- For capital costs, the prevalent approach is what it can be labeled the "segmentation" approach. In this approach, all capital items are divided into segments with common characteristics (e.g., track section between stations) or particular facilities (e.g., stations), composite costs for typical cross sections are estimated within common segments and multiplied for the length of those segments, and overall costs are estimated for particular facilities. Finally, other systemwide elements and add-on items are added (e.g., contingencies, engineering and construction management costs).

- For operating and maintenance costs, the prevalent approach is the "resource build-up" approach. This approach is usually based on past performances of similar transit systems, but at the same time includes a detailed analysis of productivity measures and service levels for
the particular context of the transportation project under analysis. In a first step, based on the service levels that one want to achieve (based, on their turn, on demand and the desired capacity, comfort, and environmental impacts), quantities are calculated so that the transportation facility will provide those service levels. Then quantities are multiplied by productivity measures to obtained the quantities required to operate and maintain the system. These quantities are multiplied by the unit costs to obtain the quantity costs, so that, by adding all these costs together, the final total costs are calculated.

The general procedure, for both capital and operating costs, therefore, appears rather straightforward. The main difficulties stem from the process of data gathering and the calculation of productivity measures. These are usually the points of conflict.

The flow chart on the next page (figure 4.1) summarizes the main components of the technical process in cost estimating. As the case studies illustrated, this graph represents more a normative process rather than a descriptive one. This is because some of the components of the graph are sometimes missing or not fully considered. That is the case, for instance, with the financial context which is barely considered at the time of calculating costs or is mostly considered a posteriori, that is, after costs have already been calculated. In this manner, the financial costs are subject to the requirements of the estimated costs rather than subjecting these costs (and, hence, the corresponding transit alternatives) to the constraints of the financial context.
Figure 4.1
Cost estimation:
Schematic representation of major elements of technical process

Socio-economic characteristics

Travel parameters (trips/person)

Demand estimation

Pricing policy (fare)

Revenues

Level of Service

Operating Plan

Level of investment (quantities)

Technology

Productivity

Unit costs

Capital costs (estimates)

Operating costs (estimates)

Financial context

Gov’t funds

Financial parameters (inflation)

Other funds, bonds

Financial analysis
As was mentioned at the beginning of this chapter, two components must be considered: the level of investment and the unit prices. The investment level comes from two main sources: the level of demand and the amount of resources available (i.e., financial context). The demand level, in turn, depends mainly on the socioeconomic characteristics of the area (that will give an indication of the number of rides per person) and how much the transit facility will cost to the users (understanding cost in a general sense, including time and comfort costs, and vis-a-vis the "generalized" cost of competitive modes of transportation on the corridor). The demand and fare levels are important in planning the design of the operating plan and knowing the stream of revenues that the transit system will get from its users. The level of revenues is complemented with the financial context to ascertain the total level of funds available to construct and operate the transit facility or system. The financial context sets the terms of how much money will cost in the future (i.e., inflation and interest rates), how much is available from higher-level institutions or other organizations, and what can be obtained by issuing bonds or other financial mechanisms.

The level of service variable serves as a cushion between the demand variable and the operating plan (and possibly investment levels for some capital items, such as number of vehicles). Several demand values would require the same level of investment, in both operating and capital terms, but would yield a different level of service for passengers. However, the level of service provided would probably affect the demand level (as less patrons would use the system if the level of service, such as the probability of getting a seat, decreases), but this effect is hardly
The operating plan and the investment level are further complemented with productivity measures for the particular technology. For each specific technology, these productivity measures, coupled with the unit prices of the different components of the transit facility, are in the final step inserted in the investment level to generate the capital and operating cost estimates. These estimates, taking into consideration the financial context and the stream of revenues, evolve into the financial analysis for each specific alternative.

4.4. Problems and Issues in the Technical Process

The previous section summarized the main components of the technical cost-estimating process. That summary may suggest that, in principle, that process consists of a clear sequence of steps that would should lead to a final set of "correct" capital and operating costs of a transit project. The process however presents some difficulties as they relate to the technical process itself. The next section discusses these difficulties and the issues that generate them.

4.4.1. The Issue of Uncertainty

The consistent underestimation of costs at the planning stage is often attributed to the lack of consideration of all the elements of the particular project. This shortcoming relates to the inherent uncertainty present in any estimating process. In project planning, several factors are highlighted as potential sources of error for estimating costs: (a) changes in the scope of the project; (b) changes in design standards; (c)
incorrect unit cost or parameter assumptions in the planning estimates; (d) bad estimating analytic methods; (e) and unforeseen problems in implementing the project. Except for the application of inadequate analytic methods, all the other factors are closely related to the uncertainty associated with elements that enter the estimating process.

The issue of uncertainty discussed in this thesis stems from factors beyond the inherent characteristics of any estimating function, as one can never predict any event or value with absolute certainty. Moreover, it is often the case with transit projects that they take several years to be planned and completed. Hence, the prediction of capital and operating costs (and the other variables upon which costs are calculated) that take place far in the future becomes very difficult, even with highly sophisticated technical resources, as the reliability of the estimates would inevitably decrease with time (as uncertainty increases).

In addition to the impossibility of predicting the future, other reasons for the uncertainty of cost components relate to the competitive (i.e., argumentative) content of the estimates (the one that allows the competition among different perspectives and different actors). The competitive content of a cost estimate usually centers in the levels or magnitudes (scope) of resource predictions rather than in the methods or assumptions used in making the estimate (that is, the focus almost always falls on (a) and (b), and less often on (c), (d), or (e), referring to the classification discussed in the first paragraph of this section). That is the case because the standards and scope of the project are the elements that eventually, if the project is constructed, would have the largest impact on the affected constituencies. Cost methods, unit costs, or how
long it would take to construct the project, though still important in defining the final cost of the project, do not ultimately influence the actual effects of the project once constructed, while the visibility and impact of the scope and standards of the project -- including operating strategies -- in attaining the pre-specified objectives are the most important. In the U.S. cases, all of the preferred alternatives were initially scaled down to the minimum requirements (in an attempt, probably, to keep capital costs at a reasonable level). Later, as communities on the corridor requested that standards be raised, costs increased correspondingly.

Another component of the uncertainty related to the competitive nature of the cost components refers to the assumptions about which institutions are in charge of covering the costs of particular elements of the transit system. For instance, in the case of Buffalo or Santa Clara County, technical analysts thought that public utilities would pay for costs of relocating underground utility lines. As it later turned out, after the inevitable legal battles, the transportation agency had to pay for those costs -- and, therefore, should have considered them as costs to the transportation project.

The case studies illustrate some attempts to tackle uncertainty from the technical standpoint. These attempts were however rather tenuous. In the case of Buffalo, the 1976 report included some sensitivity tests. These tests consisted on escalating costs by 1, 2 and 3 percent compounded annually between 1974 and 1995 to assume a differential with fare increases
Another kind of sensitivity tests involved the consideration of different incremental construction schedules. In the AMV 1976 report, conclusions were reached about operating deficits with an average fare level of $.38. With a value of $0.37, however, some alternatives that showed operating surpluses would have yielded operating deficits. This example indicates the low level of reliability of the estimates, and the negligible attempt to account for the uncertainty of the estimates.

Uncertainty also constitutes a major concern to the higher-level institutions. The institutions that eventually may fund an important part of the transit project would prefer to reduce uncertainty to a minimum. In the U.S., the federal agency in charge of financing transit projects -- UMTA -- issued a set of guidelines to calculate capital and operating costs in which they require the calculation, in addition to the best estimate, of a lower and an upper bound for all the cost items. However, the implementation of these guidelines in the case of Boston was rather disappointing as was indicated in section 3.2.1.

One possible way to reduce uncertainty is to increase the detail of the cost estimates. But this may not be possible due to the tradeoff between resources available for the estimation process and the need to go beyond conceptual engineering. In any case, an effort can be made to improve the estimation of costs of those components that are both major items and have significant uncertainties in their costs (e.g., segments whose right-of-way falls within highly developed areas, that may require

\[174\] The only conclusion related to this sensitivity analysis was: "If differential escalation of costs over revenues continues, large annual deficits would be forecast. Some administrative action would be required, such as a cut-back in feeder bus service or increase in fare levels."
unexpected mitigation measures and added physical amenities).

Another possibility that can help to reduce errors from a procedural point of view consists of starting with preliminary estimates at the very early stages of the alternatives analysis process and then periodically update the costs to reflect the accumulation of better information. The final cost estimates would come out of a continuous process rather than out of a final effort made at the end of the study. This approach, however, has the danger of taking the initial estimates for granted, keeping the final project evaluation with the initial values (maybe because those were the values everybody agreed on). For instance, in the case of Boston, the initial tag of $200 million was assumed from June 1984, the date the feasibility study was released, until March 1987, where capital cost estimates went up to almost $400 million (this was in 1986 dollars, however). The expectations created in the initial stages were based on the $200 million cap. When in April 1987, the plans to scale down the project were announced, most communities in the corridor and their elected officials reacted angrily because they felt they had been cheated.

Another approach involves performing complete sensitivity analysis involving changes in the values of those variables that appear to be more susceptible to change. This process will produce upper and lower bounds for major cost components, and will allow decision makers to assess the accuracy of the cost estimates and how much they may eventually change. By performing sensitivity analysis in both quantities and unit costs, uncertainties in quantities related to possible changes in scope, design standards, and other variables, as well as those related to unit costs, may be better perceived and taken into consideration by decision makers.
The sensitivity approach is something of a departure from usual practice. Typically, most project planning cost estimates have assumed a specific scope for the project, applied the unit cost assumptions, and used an overall contingency factor to account for uncertainties. (Often, the same contingency factor is used for all alternatives, regardless of their nature and uncertainty.) Sensitivity tests can be expanded to include not only changes in the unit cost of a particular variable but also in the analysts' or decision-makers' perceptions about the future. In the case studies, the transit projects were designed assuming the economy was going to keep growing at the same pace as in the past (or close to that pace), and that this growth was going to cause an intolerable level of traffic congestion that, in time, would limit the potential growth of the area. As these expectations were not realized, the assumptions of the study did not hold and the estimates did not materialize.

Scenario design is another methodological approach that was not formally incorporated in the technical process. This approach can complement sensitivity analysis to account for changes in broader environment-related assumptions (to take into consideration the effect of these assumptions in the value of cost variables, such as if the economy does not grow at the same pace or the price of oil decreases or inflation peaks, what would happen to construction costs and what level of investment or transit alternative would then be more appropriate if those changes take place). This methodology parallels the strategic-planning framework (highlighted in chapter 2) as it translates into a thorough incorporation of strategic issues, with a long-term view of the elements that are related

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Pearman [1988]; Meyer and Miller [1984].
to the goals the transit investment attempts to address (e.g., downtown revitalization, land use and density guidance, economic growth, etc.).

Still another way is the use of contingency factors. But these factors usually take the form of a single percentage value to be applied to the final cost figure. A more precise method would consist of assigning different contingency factors to different elements of the capital or operating cost figures, depending on their reliability. In the case of Boston, a 10% contingency was used overall for TSM elements; in the commuter rail alternatives, a 5% contingency was used for trackwork, 15% for signals and communications, and 10% for all other items; in the busway alternative, cross sections of the right-of-way had a 5% contingency while all other elements had a 10% contingency factor. This level of aggregation was deemed appropriate for the purposes of the planning process. These percentages reflected the consultants' perception about the accuracy of the group of elements depending on how close to a top-down approach the estimation of particular costs was.

A final option, as suggested earlier, consists of designing a modular, transparent computer-based model with a reclassification of cost components in terms of which are certain and which are uncertain. The model would better allow one to (i) see and explore the ripple effects of uncertainties and (ii) make changes to initial key assumptions (e.g., via a database management system). This option -- that can be used in conjunction with some of the other options indicated above -- should improve the communication among the actors with a stake in the process and also help

\[176\] This is the approach UMTA advocates in its guidelines. Ryan, et. al. [1986].
perceive the likely variations in the final costs.

4.4.2. Other Issues

Another issue that creates difficulties in the technical process is knowing exactly what elements to include as components of a transit alternative, apart from difficulty that comes from the inherent technical uncertainty. For instance, in the case of Buffalo, the capital costs did not include the necessary additions to the bus fleet that would be needed to feed the LRRT system. These costs were eventually acknowledged in response to community concerns raised at a public hearing session. This issue relates to what elements must be included at the time of estimating costs as every alternative must consider any additions or deletions that would take place for the adequate operation of the proposed transit system (e.g., feeder bus system for a commuter-rail alternative). However, it is no small task to figure out which changes the implementation of a new facility will bring in the whole transportation system. If riders are attracted from other transit services, these services may involve less operating costs (or the fleet may be reduced and sold to other transit authorities); this reduction in other services would decrease the overall costs of the project. Conversely, the new facility may need additional feeder bus lines to be able to reach the estimated demand; this need will increase capital and operating costs. At the end, the process would require the consideration of the transportation system with and without the

177 U.S. Department of Transportation [1977], page 4-8.
178 Ibid., page 10-33.
project in order to accurately estimate both capital and operating costs.

Still another difficulty in the technical process is the one generated by the phasing issue (mentioned in section 4.2). If project implementation must be carried out on an incremental basis due to funding constraints, higher project costs will probably result (because of economies of scale, since each systemwide contract would be signed in smaller parts and purchased and installed at separate times, higher costs would be incurred; and also because some elements, such as yards and shops, must be constructed anyway as soon as revenue operation begins). It may also be necessary to relocate certain elements required to operate the system from the second phase into the first increment constructed. These arguments were indicated, for instance, in the case of Buffalo where, in one of the few cases where the phasing concept was discussed, the incremental construction of one of the alternatives (the 11-mile heavy rail system) would have increased its costs due to the need to relocate a yard -- and demolish the initial structure. Interestingly, the cost of the incremental implementation was estimated a mere 2% higher than the full implementation.

Another important issue is the initial lack of consideration of the financial context surrounding the transit project. This deficiency,

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179 A similar approach should be applied to ridership, as analysts must compensate ridership gains on some lines with losses on others. In other words, ridership estimation would involve the calculation of overall figures with every transit alternative being considered and compare those estimates to the do-nothing alternative (i.e., the alternative with no additional investment to the transportation system in place besides the standard needs being already applied to it).

180 Niagara Frontier Transportation Authority [1976], page 104.
coupled with a frequent overestimation of demand, tends to yield investment levels higher than may actually be required. But in order to keep costs low and eventually obtain the approval of funds from higher-level institutions, productivity measures tend to be rather optimistic, and design standards and unit prices rather low. Once the project is started, the transportation agency hopes that involved institutions would see the construction to full implementation.

In the U.S., conversations with UMTA officials indicated that, from their points of view, the lack of consideration of the financial context was one major reasons for posterior financial problems and strained relations between UMTA and the local institutions. Once the project is started, the local institutions realize they cannot afford the system, and hence start requesting further funds; local politicians then take the lead in requesting any additional funds needed to complete the project. Regardless of these perceptions, what actually happens is not so much that the financial context was not considered (in all the three U.S. instances, the case studies illustrated how adequate financial provisions were made at the local level to meet the local share of capital costs) but rather that this consideration was not put in the context of possible increases in cost estimates. Therefore, the optimistic cost estimate was more the source of the problems, than the fact that the financial context was not carefully considered.  

Nevertheless, the system seems to work well for the local interests if their purpose is to pre-select a project and then build the political base necessary to persuade a higher-level institution (e.g., UMTA) to pay for that project.
4.5. Summary and Conclusions

This chapter included a review of the technical process of estimating capital and operating costs for the construction of transit facilities, identifying its main components, the major approaches, and the main difficulties and issues involved in undertaking these approaches. The discussion showed how the cost-estimating approach must be tailored to the decision environment, how cost classifications can help understand the implications of changes in demand estimates, and how the management of cost information can help organize and structure the cost estimating process. In another section, the major components of this process were identified along with its relationships. Figure 4.1 set the path to a broader discussion of the implications of uncertainty in the cost estimating process and the possible means to deal with it. Finally, section 4.4.2 presented other issues, such as the phasing of alternatives or the consideration of the financial context within which the estimating function takes place, which usually create some difficulties in the technical task of estimating capital and operating costs.

This chapter illustrated that certain difficulties in the technical process leave room for deviations from the rational ideal of comprehensiveness and impartiality, although specific actions could be taken to get closer to that ideal. The next chapter discusses the decision-making process and elucidates other components of the overall planning process that can affect the technical process and how this process is undertaken. Nevertheless, as the design of the technical process -- in terms of which approach to follow, or how to deal with uncertainty, etc. -- affects the technical process itself, the perception of what the role of
the technical analysis is by the ultimate users of it -- i.e., the decision makers -- constitutes a fundamental element to understand and structure that technical process. In the end, the success or failure of the cost estimating process depends on how useful it is to achieve a particular role in the decision-making process, rather than simply its accuracy or the sophistication of its technical developments.
5. DECISION MAKING: PERSPECTIVES, ELEMENTS, AND PROBLEMS

5.1. Introduction

The previous chapter discussed the main technical approaches and elements that are involved in the cost estimating process. That chapter also highlighted the major technical issues that must be taken into account for an effective cost-estimating process. This chapter focuses on the elements of cost estimating as they relate to the decision-making process.

From the previous chapter, one may think that the cost-estimating process consists of a clear set of steps that, once some technical difficulties are overcome, leads to the final, accurate cost estimate for the specific project. The reality however, reflects a different picture, as the history of chronically underestimated capital and operating costs in large transportation projects proves. Most of the studies that have attempted to explain cost underestimation have looked at this history from a technical standpoint, using statistical analyses to explain and tackle the issue of underestimation. However, the case studies illustrated (and the analytical framework presented in chapter 2 suggested) that the investigation must also encompass other components of the estimating process to find out where the "disturbances" come from. The other set of components includes both internal and external effects within the institutional and political dimensions of the transportation planning process.

The decision-making process inherently involves organizations and

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\(^{182}\) Table 1.1 presented some instances. See also Merewitz [1972], Charles River Associates [1983], and Pickrell [1988].
individuals, whose perspectives are very different from those of the "rational" systems analyst. Allison's *Essence of Decision: Explaining the Cuban Missile Crisis* [1971] presented these perspectives by illustrating three different possible models to "see" a single decision process.

Simon's *Administrative Behavior* [1976] related the limitations that are unavoidably present in any human decision making process and how these limitations affect the pure rational system perspective. 183

The rational model is based on Locke's positivism. The characteristics and assumptions of the positivist perspective include: the ability to abstract problems; the certainty of solving those problems; the optimality of the results; the possibility of reducing problems to a very limited number of elements and the interactions among them; the reliance on data and models; the possibility of quantifying information; objectivity (or assumption that the analyst is an unbiased observer outside of the system he or she is analyzing); the ignorance or avoidance of the individual (or averages can be used to generate effective results); and a view of the time that is linear (with no consideration of differential time perceptions). 184 The success of this method and its paradigms in applied mathematics and modeling gradually led to the extension of its use beyond science and technology, to society and all its systems.

The rational model was discussed in the second chapter. The

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183 "The central concern of administrative theory is with the boundary between the rational and the nonrational aspects of human social behavior. Administrative theory is peculiarly the theory of intended and bounded rationality -- of the behavior of human beings who satisfice because they have not the wits to maximize." Simon [1976], p. xxviii.

184 Linstone [1984], pp. 7-24.
application to the transportation planning process indicated that the elements of comprehensiveness and impartiality of that model have limitations within the realm of that process. The main reason derives from the particularities of the transportation planning process such as its interdisciplinary nature, the scope of its impacts, and the fuzziness of the line between its technical and political arenas. These characteristics make the decision-making environment a complex one, one where, in addition, it is hard to define who the decision makers are.

By contrast, in the private sector context, the application of the rational paradigm has been rather successful. But transit projects (as mentioned in chapter 4) are public projects and, as such, present characteristics that, to a larger or lesser degree, differ from those that exist in the private context. The following is a list of some differences between the public and the private context as they relate to the decision-making environment: (a) public decision makers tend to have a relatively short time perspective delineated by political necessities, the political calendar, and the short-term budget cycle; (b) there is little if any agreement on the standards and measurement of performance to appraise a public decision maker; (c) in the public arena, emphasis tends to be placed on providing equity among different constituencies to the detriment of efficiency, although both equity and efficiency can be part of a rational analysis; (d) public decision makers tend to be more open and exposed to public scrutiny and they must contend regularly with the press and media (and their decisions are sometimes anticipated by the press); (e) public

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185 The length of service for politically-appointed public decision makers is often relatively short.
decision makers often seek to mediate decisions in response to a wide variety of pressures and must often put together a coalition of inside and outside groups to survive; in addition, they tend to regard themselves as responsible to many superiors instead of a single higher authority; (f) public decision making is often subject to close scrutiny by legislative oversight groups or even judicial orders, constraining executive and administrative freedom to act; and (g) a variety of other factors also affect and constrain decision making in the public arena such as the difficulties of implementing change, the resistance to change in large-scale bureaucracies, and the frequent imperfect control and coordination among different public institutions 186.

Added to these characteristics there are two more that make the transportation decision-making process even more complicated. The first one is the ever-changing focus of the political agenda and of public priorities. The brief history of transportation planning presented in chapter 2 is a good example of the continuous change in focus. The second one is the frequent inseparability of decisions. For instance, the decision to revitalize the downtown area and reduce congestion may be inseparable from that of constructing some sort of transit system.

186 Kelman [1987], Scott [1981], Lipsky [1980]. There are still other characteristics that were not listed above because they do not directly relate to the issues discussed in this thesis. Some of these additional characteristics are: (a) decision makers do not usually have the imperative to train a successor (because of political reasons that affect both the incumbent and the successor); (b) the public decision-maker must act with constraints on personnel mobility and changes, since civil service, union contract provisions, and other regulations complicate the recruitment, hiring, transfer and layoff or discharge of personnel to achieve the decision-maker's objectives; these constraints, in addition, tend to create conflicts between civil service officials and political appointees; and (c) the insufficient power and authority decision makers can have over autonomous units.
The case studies illustrated many of these issues. A full account here would unnecessarily lengthen the scope of this chapter. A few instances should suffice to indicate how, within the transportation planning context, decision makers are affected by the characteristics of the public arena. Most of the cases illustrated the short term focus of the arguments as the major criteria for the selection of the alternative targeted cost-effectiveness measures, the value of travel time, or the visibility of the city and its economic viability. However, in order to attract constituencies and reach an acceptable level of equity, stated objectives tended to stress longer term elements, such as land use changes. Frequent clashes resulted as the different layers of the decision-making process disagreed over which perspectives were the most important for the selection of the preferred alternative. Shifting priorities were a consequence of those clashes (in addition to general trends in the societies affected by the transportation plans) and were reflected in the long periods of time it took to fully implement the initial proposals. The visibility and scrutiny of the decision-making function was reflected by frequent turning points along the process (such as the case of phasing in Boston), as well as by the emphasis on keeping the affected constituencies informed about the technical results. Finally, the permanence of initially-preferred proposals -- for more than fifteen years, in some cases -- reflected the difficulties of changing the course of action. These difficulties come from several sources including the complexity of the technical process, the time and effort required to ensure the support of constituencies, and the inseparability of decisions. In other words, initially-preferred proposals do not substantially change along the planning
process because, as time passes, it becomes more and more difficult politically, emotionally, and technically to do so.

5.2. Decision Making: Theories and Issues

This section presents a review of the major theoretical elements that refer to decision-making theory as a background for the subsequent discussion of decision making in transportation planning and the presentation of the theoretical framework in chapter 6.

5.2.1. Decision-making Theories, Perspectives, and Elements

Decision-making theories can be classified at two different levels: individual and general. At the individual (micro) level, two main streams of theory have been developed: those that try to define what the decision-maker ought to do (prescriptive or normative theories) and those that try to define what they actually do in practice (descriptive theories). The former are included within the tradition of operations research methods and encompass the area of decision analysis. The latter include the areas of psychology and behavioral studies.

The distinction between both becomes blurred when each stream tries to address the concerns of the other. For instance, a normative model may adequately predict what an individual decides to do if this individual follows the dictates of the model; in the opposite direction, descriptive considerations have changed the content of normative models. Contemporary normative models for decision making are little more than sets of rules designed to ensure that acts will be coherent or internally consistent with

\[187\] Von Winterfeldt and Edwards [1986].
one another in the pursuit of the decision maker’s goals.

At a more general (macro) level, the rational-actor model of decision making corresponds to the first stream of theories (normative) as it tries to prescribe the outcome of every decision-making process based on a given set of assumptions. Satisficing, organizational, and political (or personal) theories fit more within the psychological and behavioral theories (prescriptive) as they try to explain decisions based on empirical experiences.

Decision-making theories can be understood as a continuum. The rational-actor model misses some aspects such as the political interests of the decision maker or the pressures from the organization the decision maker is part of. By adding other "less-quantifiable" elements, we could think of any decision-making process as a maximization of the "stakes" that the many actors involved in the process have in it. "Stakes" include everything from the financial costs to some actors, to the political gains to others, and to savings in travel time to still others, to name just a few. The problem is not only that it would be very difficult to define some of those stakes -- for instance the value of political gains -- but also impossible to identify all the actors affected.

In spite of its practical difficulties, the idea of the continuum allows us to accept that an outcome that we may assess as an "irrational" decision is actually "rational" from the perspective of a different point in that continuum. Allison’s [1971] explanation of the same outcome from three different perspectives reflects the idea that the "political" or "organizational" perspectives are not necessarily irrational but just rational from those perspectives (i.e., "rationality" is always present but
its definition changes depending on the perspective)\textsuperscript{188}.

The acknowledgment of the continuum can help better understand planning outcomes that evolved as a consequence of public decision-making processes. The predominant definition of rationality -- the (economic) utilitarian definition -- is not enough to explain particular instances of those outcomes. Utility functions do not allow for the straightforward encapsulation of a multiple perspective approach encompassing the technical, organizational, and personal perspectives\textsuperscript{189}.

The need for different perspectives also stems from the fact that different explanations -- or interpretations -- of a phenomenon are often possible\textsuperscript{190}. These different explanations originate in elements such as: (1) the background of analysts and the specificity in the definition of their tasks (the personal perspective), (2) the type of organizational structure (the bureaucratic perspective), and (3) the type of environment (the socio-political perspective).

The background of the analysts and the specificity of their tasks relates to how they perceived their roles in the planning process or whether or not these roles are pre-specified\textsuperscript{191}. In the U.S. cases, analysts, indubitably with a respectable professional competence, did not

\textsuperscript{188} Simon [1976] suggests a similar theoretical construction as an alternative to avoid the complexities of defining rationality is "to use the term 'rational' in conjunction with appropriate adverbs." Then we can have a decision that is "objectively" rational, or "subjectively" rational, or "organizationally" rational, or "personally" rational. Simon [1976], pp. 76-77.

\textsuperscript{189} Linstone [1984].

\textsuperscript{190} Scott [1981]; Allison [1971].

\textsuperscript{191} Drake [1973] provides a fuller discussion of this element in the context of several transportation planning exercises in the U.S..
perceive their tasks as purely technical but more as collaborative with the
decision-making process and possibly influencing the outcome of the
planning process; by contrast, in both the Madrid and La Paz case, the
analysts did perceive their role as separate from the decision-making
process. This element is also influenced by the definition of the goals to
be achieved by the decision-making process and how widely they are
accepted. In the U.S., some goals are not precisely defined because they
are not widely recognized but rather controversial -- that is the case, for
instance, with the issue of the land use effects of LRT and fixed guideway
systems. As the case studies illustrate, with different broad objectives
being stressed for similar types of projects and by different groups of
actors, analysts are often left to fend for themselves and find a way to
reconcile different goals to be achieved with a transit investment. The
lack of specificity in goals and tasks, on one hand, does not help
establish a solid unique basis for a formal decision-making process. On
the other hand, the lack of specificity may be inevitable to reach an
outcome within particular planning environments (e.g., the U.S. cases).

The lack of specificity in the U.S. context contrasts, paradoxically,
with the high-degree of formalization of the planning process (at least
compared to the the less-formalized nature of the other two cases). This
contrast creates strains and fewer possibilities that the formalization is
widely accepted. By comparison, in the cases abroad, the low level of
formalization allowed the process to adapt to the conditions of the
particular projects. Formalization also relates to the roles of the actors
of the planning process and the relationship among them. Formalization,
when prescribed independently of the personal attributes of individuals
occupying positions in the decision-making structure, is an attempt to make behavior more predictable by standardizing and regulating it but, again, is likely to clash with the different backgrounds and styles of the actors.

Another important element of the technical-estimation process is the organizational context within which that process takes place. This context refers to the institutions in charge of carrying out the technical elements of cost estimating, those involved in deciding which alternative to pursue, and the relationship among them and with the rest of the institutions involved in the broader planning process.

Usually, the scale of the projects that are the subject of this thesis requires the involvement of several institutions and, mainly, of consultants outside the public transit agency. In the U.S. cases, the technical studies were done by outside consulting firms; the transportation agencies supervised the consultants' work. Once the preferred alternative was selected, other institutions -- engineering firms and construction companies -- constructed the transit facility. Once constructed, the facility was operated by the transit agency. This process presents unavoidable discontinuities because the transit agencies do not have the capabilities to carry out the technical studies and the construction themselves. These discontinuities open up the possibility of collusion between transit agencies, decision makers, and technical consultants. Collusion stems from the interdependence among these actors as each needs the others to work on projects, to garner support for decisions, or simply to acquire technical information (e.g., analysts gather

\[192\] In the case of Boston, there existed a "parent" consulting firm coordinating the efforts of several others consulting firms, each one in charge of a different technical element.
information from the transit agency they are working for to calculate particularly productivity values and operating costs). Collusion has the potential for encouraging each actor to please the others to support their preferred outcomes; it is almost always difficult, substantively and organizationally, as organizations or individuals must respond to other requirements that unavoidably influence how the work -- technical analysis, decisions -- is performed.\footnote{193}

This element was present in the U.S. context where the need to satisfy different audiences (mainly, state and federal requirements) forced analysts, decision makers, and transit agencies to steer the analytical studies to fit that need. In the case of La Paz, the attempt by the analysts to avoid that collusion created some difficulties in the process whereby technical results were not easily accepted by decision makers.

The third major element that affects the explanation of decision outcomes is the environment within which the planning process takes place. Does it take place in a stable environment with clearly defined goals or in a dynamic one with changing priorities? The latter easily applies to the transportation planning domain where, for the last twenty years, goals have been continuously added to transportation plans and have often become

\footnote{193} The discontinuity also affects the internalization of the responsibilities of each actor as they can easily put the blame on the institutions or individuals in charge of other parts of the process. The increasing role of legal liabilities on technical studies may enhance the internalization of responsibilities (Innes [1988]). This approach, however, may prove inefficient as lawsuits lengthen planning studies and increase initial estimates of capital and operating costs, as the U.S. cases illustrated. It remains to be seen if this approach can efficiently and effectively work as a deterrent to avoid bias in the technical results.
looser and wider. The broadening of transportation plans has been a consequence of an environment with evolving needs, expectations, and policies (which, for instance, in the U.S. has been reflected in the changing emphasis of the federal government).

The instability of the environment affects the planning process in two ways: one relates to the environment as a source of information; the other relates to the environment as a setting for power relations, compromises, and conflicts. As to the environment as a source of information, the instability generates uncertainty in the technical process -- cost estimates depend on a variety of data gathered from the environment (see figure 4.1). As to power relations, the instability allows actors to act on that uncertainty in their attempts to support their views about the objectives to be achieved with the transit plans.

5.2.2. A "Good" Decision-Making Process

In light of these multiple perspectives, it becomes difficult to define what a "good" decision-making process ought to be. Wheeler and Janis [1980] state that a "good" decision-making process is that process that abides by the right rules. Von Witerfeldt and Edwards [1986] argue that a common but often misused idea is that decisions, and hence rules for decision making, should be evaluated on the basis of their results. These authors further state that the quality of decisions really means the quality of the process by which they are made, and they can only be evaluated on the basis of information available before their outcomes occur.

194 Altshuler [1979].
or become certain -- in other words, the decision-making process would be evaluated with foresight, not hindsight.

This approach shifts the question from the outcomes to what the "right" rules are. The difficulties of defining the right rules, nevertheless, make any arguments that link the outcomes of decisions to their evaluation powerful and influential 196. For decisions whose outcomes are rather certain, those arguments are straightforward; for decisions made under uncertainty, the arguments are controversial and elusive and are difficult to apply in a generic fashion. This latter situation is the one that typifies the transportation planning process.

Five major stages of a decision making process can be distinguished 197: (1) perception of problem ("need"), and acceptance and initiation of the decision process; (2) search for and identification of alternatives (with little evaluation done at this time); (3) evaluation of alternatives with considerable effort dedicated to searching for dependable information relevant to the decision; (4) commitment after the reexamination of all the information (and figuring out how the decision will be implemented including contingency plans in case any risks materialize); and (5) adherence to the decision (including the anticipation of likely setbacks, preparation of countermeasures, and, in case a serious setback takes place, ascension of a new challenge to go through another cycle of five stages to decide on a new course of action). Within this process, decision makers,

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196 The comments gathered from the interviews and literature related to cost underestimation support this argument as the evaluation of transit projects is usually done on the basis of the comparison of estimates with actual outcomes rather than on the basis of the process that led to the final decision.

197 Wheeler and Janis [1980].
based on the costs of the alternatives, their cost-effectiveness, and other -- not necessarily less important -- factors, must select a course of action. In the decision analysis tradition, the decision maker would construct a decision tree and, based on the probabilities that each option has, would come out with different payoffs and end up with a "best" course of action. The field of multiattribute evaluation develops the theory of the calculation of the payoffs and the selection of the "best" alternative. This approach relates to what Pfeffer [1976] calls the application of universalistic criteria.

The universalism-particularism dimension describes the extent to which decision outcomes are affected by the particular social relationship existing between the decision maker and those who are affected by the decision. When consensually agreed-upon, well-defined standards are available for evaluation, decision-making outcomes will be based upon those standards and universalistic criteria would be applied. However, in the transportation planning process, where the absence of shared criteria is usually the norm -- the case studies illustrated how the emphasis and objectives were different for different actors and at different times --, processes of social influence will account for part of the variance in decision outcomes.

Particularistic criteria -- criteria which derive from the particular perspectives or goals of the contending groups -- will be used more in decision making under conditions of uncertainty. In the transportation planning process, characterized by uncertainty about demand, costs, and which goals to achieve, social influence tends to overshadow technical

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198 Keeney and Raiffa [1976].
considerations and the use of universalistic criteria. These conditions were clearly illustrated in the U.S. case studies in Santa Clara County and Buffalo where projects were ultimately approved and carried forward not on the basis of the technical studies but because of political mandates that came out of the U.S. Congress.

When particularistic criteria plays a role in the process, other decision-making mechanisms besides the technical process become important. These mechanisms include: implicit exchanges or political logrolling (to vote for someone’s project, because this someone will vote for mine in reciprocity), familiarity and likeness for someone else’s project, and informal communication. Whether the process operates through any of these mechanisms, influence will be greater the more uncertain the decision situation is (and, hence, less likely to have objective information to anchor one’s judgements). Uncertainty decreases the extent to which universalistic standards can be applied. Nevertheless, the visibility of the allocation process, the information generated -- however uncertain --, and the outcomes will tend to ensure that some kind of universalistic criteria are employed. Organizations, then, will be likely to employ both universalistic and particularistic criteria in their decision-making processes.

This dichotomy about how different criteria are applied in decision-making highlights the difficulties of defining the right rules of the process -- aside from following a set of stages, which may be hard to achieve anyway when some particularistic mechanisms play the major role. In chapter 2, it was argued that "good" decisions are those that are made on the basis of the right information and in a democratic fashion. Since
decisions are made on the basis of a set of (explicit or implicit) criteria, how these criteria are defined and developed ultimately affects the information basis and the level of "democratization" of the decision. The definition of evaluation criteria then becomes crucial in the light of the uncertainty of the elements of the technical process. If the outcome of the decision has been initially predetermined, due to general consensus, pressures, or undemocratic practices, a "good" process may be precluded. That was, for instance, the case of La Paz, where the pressures to prove the worthiness of a particular alternative for getting the approval for the necessary funding thwarted a satisfactory decision-making process from the perspective of the framework discussed here.

5.3. Decision-Making in Transportation Planning

The discussion of the case studies illustrates the many institutions that are involved in the planning and implementation of any fixed-guideway transit system. These institutions can be categorized according to the roles that they play in the process: (a) providers of capital and operating funds or subsidies (e.g., federal and state governments in the U.S.; the World Bank for infrastructure projects in developing countries; the central government in the case of Spain); (b) certifiers of the process and project approval (e.g., UMTA or state agencies in the U.S.; the World Bank and central governments in developing countries; the central government in Spain); (c) issuers of regulations or guidelines (e.g., U.S. Congress and U.S. DOT in the U.S.; the parliaments and central governments in developing countries and in Spain); (d) providers of technical support and disseminators of information (e.g., UMTA or state agencies in the U.S.; the
World Bank and other international agencies in developing countries; the central government in Spain); (e) budget allocators (e.g., federal and state budget offices; central, state, and local governments in developing countries and Spain); (f) implementors (e.g., state and local departments of public works or departments of transportation; transit authorities with their managers, technical staff, labor force and unions; and manufacturers of transit technologies); (g) analysts (e.g., consulting agencies and specific departments in transit agencies); (h) political lobbyists and other influencing actors (at all the levels of government, such as interest groups, citizen groups, transit unions, etc.); and (i) the business community 199. The final selection comes out of the interaction of these actors, concurrently with the development of the technical analysis.

Before the final alternative is selected for implementation, several other decision processes take place that ultimately may affect the final alternative. These decision processes include: (a) which alternatives to consider, (b) which agency or agencies will supervise the project, (c) which organizations will undertake the analysis project and which institution(s) will pay for it, (d) who will be formally involved in commenting the analysis study, (e) which methods will be followed in the study, and (f) which criteria will be used as the basis for evaluating the competing alternatives. Except for (f), which, as in the U.S., may be established by some sort of statutory guidelines, institutions at the local (regional) level usually have the widest choices in these matters, subject to the constraints generated by the actors at other levels (e.g., the funding institutions) and the resources available.

199 Hamer [1976].
Figure 5.1 summarizes the major elements of current planning processes from the perspective of the decision-making process and the interaction of the institutions involved in such a process. Initial proposals are generated as reaction to a perceived "need" for transportation improvements. For instance, in Boston, the Old Colony project had existed as a plan since the abandonment of the rail line in 1959. Only in 1984, when congestion levels on the corridor were assessed as unbearable, and the day the largest reconstruction effort in the state of Massachusetts was approaching, the state government activated the project and started the necessary feasibility and environmental studies. The "need" was then expressed as a way to reduce congestion on the major highways on the corridor, although later it was perceived that automobile volumes would not be reduced on those major highways but rather on the local streets parallel to those highways. The perceived "need" was also a consequence of the state's political necessity to gain support for the major reconstruction project. In exchange for the rehabilitation of the Old Colony project, politicians from the fastest growing region of Massachusetts and their constituencies were expected to be willing to support the state's major engineering undertaking in its history.

Once the "need" is established, preliminary alternatives are defined. There always exist an initial preference for certain types of technologies, and the alternatives that include these technologies are put up front and

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200 This refers to the reconstruction underground of a major elevated highway crossing the center of the city (the Central Artery). The project was slated for construction in 1990 and was going to disrupt the whole transportation network. Particularly from the South, alternatives were needed to provide access to Boston's central business district.
Figure 5.1
Cost Estimation: Schematic Representation of Institutional and Decision-Making Processes

Initial proposals ("need")

Preliminary definition of alternatives

Initial preferences

Preliminary demand and cost estimates

"Need" for additional government funds

Involvement of higher levels of government (rules and processes of funding institutions)

Final definition of alternatives

Bureaucratic process

Formation of study techniques (technical decision process)

Data gathering and analytical process

Formal steps

Political support at higher levels of government

Environmental impacts

Community and local support

Constituency development

Thresholds (demand, costs, other impacts)

Selection of preferred alternative

Capital and operating costs (final estimates)

Constituencies' preferences
may even give the name to posterior analytical studies (e.g., in Boston, "Old Colony Railroad Rehabilitation Project"). These initial preferences already place some other alternatives in a disadvantaged position. In the meantime, constituency development is started by the generators of the "need" (that are the only ones that at the moment have a stake on the project). Parallel to these events, some preliminary estimates of capital and operating costs come to light based on feasibility studies or indications from interested parties (e.g., from providers of particular technologies, like in the case of La Paz). These preliminary estimates easily become hard currency, even if the studies they are based on clearly state that they are only approximations and many items are not accounted for (e.g., in the case of Boston, the feasibility study indicated the limitation of the $200 million estimate for the full alternative; for almost three years however, this figure was the only one mentioned by all the involved institutions).

Based on the preliminary cost estimates, a "need" is perceived for additional funds. These funds must be provided by higher-level institutions that adhere to specific rules for approval. The "need" is usually acknowledged not so much because of the transportation project itself but rather because of the opportunity to bring "high-level" (e.g., federal, in the U.S.) dollars to the area. This factor overrides the others in the case of distressed areas, as in the case of Buffalo. In other situations, the real lack of funds to afford the project is the main element. The decision to try to obtain the funds and go ahead with the rules of the higher-level institution is not an obvious one because the whole process from planning to final implementation becomes much longer
and, ultimately, affects the overall costs of the project (due to inflation, more opportunities for legal battles and changes in scope, and lost revenues). But the impossibility of collecting the necessary funds at the local level or the "need" of not missing the opportunity to obtain "cheap" funds -- that is, funds that cost less to the local taxpayer since they are partially covered by a higher-level institution --, eventually persuades the decision makers to pursue the required (bureaucratic) process of the higher-level institutions.

Once the decision to pursue the process established by those institutions is made, these high-level institutions become another important actor in the overall planning process. The definition of the alternatives must be agreed upon with them, although implicitly the initially preferred alternatives will still keep their preeminence in the planning study. Additionally, agreements upon the study techniques and the schedule for the delivery of specific elements of the final analytical report must also be reached.

The formal steps of the analysis process take place simultaneously with the building up of local and community support for the project. Some opposition probably arises and for that technical documentation must be quickly prepared. This forces analysts to work at a fast pace, trying, against all odds, not to fall behind the political environment. When opposition surfaces against the implicitly preferred proposal(s), the decision makers usually indicate that the studies are still inconclusive on the issue and that further analysis must be undertaken to address all the concerns. Consensus building is a major effort at this stage since continuous support from the funding institutions largely depends on the
perceived support from the communities the transit project passes by. While the analytical study takes place, the decision makers must also spend time at other levels of government (parallel to those of the funding institutions), gaining additional political support for the project. If a major representative from the region where the project is located has some leverage in the committees or agencies in charge of allocating funds for the project, it is more probable that the funds will be approved. For instance, in the case of Buffalo, the area's representative in the U.S. Congress, was a member of the public-works committee, the committee that allocates federal funds for urban-development infrastructure projects. His presence in the committee help funnel federal funds for Buffalo's LRRT line.

In the meantime, the analysis process continues. Data, particularly those related to capital and operating costs, are gathered, and methods (models) are applied to generate the demand, revenue, and cost figures. In addition, environmental studies are undertaken to quantify and qualify the effects the transit project will produce in the corridor. Local concerns must now be addressed, and new cost figures must be calculated since the initial preferences did not consider the apparently "endless" wants of the affected communities. The case studies clearly illustrated this issue as elements such as station upgrading, double tracking, landscaping, additional parking spaces, etc. had to be added along the process to meet the concerns of the affected communities. These changes in project scope produce an escalation on capital and operating costs. They will not be the last, since later on, during preliminary engineering, new additions will take place as geological conditions are surveyed, operational strategies
are refined, etc., and new demands are likely to be made from the affected communities.

But costs cannot be escalated without considering the requirements of the funding institutions, particularly threshold values that must not be surpassed to obtain the approval of the funds for the project. It is now when a give-and-take process occurs between the analysts and the decision makers, otherwise the analysis process may end up suggesting an alternative different from the initially preferred one and the one that has already taken so much effort, politically and emotionally, to gain support from the interested constituencies. This situation encourages a good dose of deliberate or accidental "optimism" in the calculation of the technical figures, particularly those related to demand and cost estimates, in the direction of putting the initially-preferred alternative at an advantaged position.

Decisions of higher-level institutions about whether or not to fund a project are usually based on some sort of cost-effectiveness measure. In La Paz, the internal rate of return was the measure frequently asked for by the World Bank to judge the adequacy of each alternative (by itself or vis-a-vis the other alternatines). The problem with this measure (in addition to the usual complaints about its adequacy to judge investments) is that unless the project yields net profits (that is, revenues are larger that total annualized costs), which is hardly the case with any transit system, rates of return are negative. In the U.S., the federal government uses two major performance measures to screen alternatives: (a) the estimated number of riders on the corridor (a minimum is necessary to proceed with a proposal), and (b) the cost per added rider (this cost must not be higher
than a specified threshold).

Table 5.1 shows the total annualized cost per rider for the transit projects discussed in chapter 3. The total annualized cost was calculated adding the estimated annual operating cost to the annualized capital cost (assuming a 30-year life with an interest rate of 10%). The cost-effectiveness measure was calculated dividing the total annualized cost by the ridership estimates or the number of rail boardings (in the case of actual figures). This cost-effectiveness measure differs from the one

<table>
<thead>
<tr>
<th>Transit Proposal</th>
<th>Capital Costs Estimates (000's)</th>
<th>Operating Costs Estimates (000's)</th>
<th>Annual Annl'n Ridership Costs (life=30 yrs)(curr.)</th>
<th>Cost-Ridership effct. factor index index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffalo (76)</td>
<td>336,000</td>
<td>24,400(1)</td>
<td>33,580</td>
<td>0.1061</td>
</tr>
<tr>
<td>Buffalo (78)</td>
<td>449,800</td>
<td>24,400(1)</td>
<td>23,725</td>
<td>0.1061</td>
</tr>
<tr>
<td>Buffalo (87)(2)</td>
<td>551,800</td>
<td>11,555</td>
<td>8,400</td>
<td>0.1061</td>
</tr>
<tr>
<td>Santa Clara (81)</td>
<td>180,044</td>
<td>8,786</td>
<td>13,080</td>
<td>0.1061</td>
</tr>
<tr>
<td>Santa Clara (84a)(3)</td>
<td>372,000(4)</td>
<td>8,786(5)</td>
<td>6,000</td>
<td>0.1061</td>
</tr>
<tr>
<td>Santa Clara (84b)(3)</td>
<td>411,000</td>
<td>8,786(5)</td>
<td>6,000</td>
<td>0.1061</td>
</tr>
<tr>
<td>Santa Clara (87)</td>
<td>559,000</td>
<td>8,786</td>
<td>6,000</td>
<td>0.1061</td>
</tr>
<tr>
<td>Boston (feasib.84)</td>
<td>181,200(6)</td>
<td>16,250</td>
<td>2,505</td>
<td>0.1061</td>
</tr>
<tr>
<td>Boston (87)</td>
<td>360,975</td>
<td>17,885</td>
<td>3,936</td>
<td>0.1061</td>
</tr>
</tbody>
</table>

Note: The years after the name of the case study refer to the year of publication of the technical report related to that case study (see Technical Documentation).
1 Buffalo 76 and 78 operating costs include the costs associated with the extensions to the bus system that would be necessary to serve the LRTT stations.
2 Buffalo 87 are actual figures.
3 Santa Clara 84 ridership is an revised estimate (from an 1987 report).
4 Santa Clara 84a capital costs are those for the project without the transit mall.
5 Santa Clara 84 and 87 operating costs are assumed similar to those in the 1981 report.
6 Boston 84 capital costs do not include land acquisition costs, engineering, administration and contingency costs.
suggested by UMTA in two elements: (a) the numerator considers neither the
time savings for existing riders nor the local contribution to the project,
and (b) ridership refers to total ridership and rail boardings rather than
net new riders (i.e., net of those that would take place in the base (TSM)
alternative). The first element tends to yield values that are higher for
the measure included in table 5.1; the second tends to yield values that
are lower. Nevertheless, the figure illustrates how the cost-effectiveness
measure increases dramatically from initial proposals to later reports. In
the case of Boston, the high value of the cost-effectiveness measure is
probably another (unspoken) reason for the major difficulties the project
is having in obtaining federal funds (and definitely one major reason for
the increase in the local share above the statutory one)\textsuperscript{201}.

The cost-effectiveness performance is not the only cost-related
criterion that is considered in the decision. The studies usually advocate
capital-intensive projects, such as LRT systems, on the basis that these
systems would yield higher benefits due to their lower operating costs.
The belief is that normalized values of operating-costs (i.e., operating
costs per passenger, passenger mile, revenue vehicle, revenue vehicle mile,
etc.) are much lower for capital-intensive systems. As a consequence of
the lower normalized operating costs, total (normalized) annual costs
(i.e., operating costs and annualized capital costs) are likely to be lower
for capital-intensive projects. This belief generates some rather
optimistic expectations about the performance of the system. Table 5.2 and

\textsuperscript{201} UMTA regulations set a maximum (conservative) value of $10.0 for the
cost-effectiveness measure (that, as has been said, is calculated in a
manner different from the one shown in figure 5.2).
5.3 illustrate this situation for the U.S. cases. The systems planned usually are presented with operating statistics where normalized costs are expected to be lower than those of other systems. Actually, an interesting situation takes place. On the one hand, operating costs per revenue vehicle tend to be close to the maximum figure for existing systems while operating costs per revenue vehicle-mile tend to be lower than the minimum figure for existing systems. This situation seems to suggest that operating costs tend to be underestimated and the estimated number of vehicles for operating the system tends to be underestimated as well (which reduces the amount to be spent on capital costs).

Furthermore, as passenger demand is overestimated, operating statistics based on demand estimates put capital-intensive systems at an advantage. However, if the estimated demand is not realized, those operating-performance indicators do not hold true any longer. Thus, another important element on the basis of which decisions are made tends to be unrealistic. Nevertheless, these performance indicators constitute an additional powerful argument to favor particular technologies and put the project forward.

In conclusion, this section has illustrated how the need to justify the project on the basis of a particular set of criteria mobilizes the decision-making and analysis processes in an attempt to prove the worthiness of the alternative that, from the outset, has received the strongest preferences. Once the performance thresholds (in terms of cost-effectiveness measures, for example) comply with specific criteria, the alternative can pass the test of the higher-level institution and the final decision can be made on the selection of the preferred alternative. An
agreement must then be reached with the funding institution to proceed into preliminary engineering and on which percentage of the final capital costs will be covered by that institution.

Table 5.2
Comparative statistics from several systems in the U.S.
(Fiscal year ending between 01/01/83 and 12/31/83)

<table>
<thead>
<tr>
<th>Commuter rail systems</th>
<th>Total revenue vehicles</th>
<th>Tot. oper. expenses ($000)</th>
<th>Vehicle revenue miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pittsburgh PAT</td>
<td>12</td>
<td>$1,924.1</td>
<td>290,444</td>
</tr>
<tr>
<td>Detroit SEMTA</td>
<td>35</td>
<td>$2,846.2</td>
<td>157,872</td>
</tr>
<tr>
<td>Chicago RTA</td>
<td>1,023</td>
<td>$194,738.6</td>
<td>19,447,773</td>
</tr>
<tr>
<td>Newark NJT Corp.</td>
<td>1,206</td>
<td>$131,460.0</td>
<td>27,526,438</td>
</tr>
<tr>
<td>Boston MBTA</td>
<td>259</td>
<td>$44,882.6</td>
<td>7,202,999</td>
</tr>
<tr>
<td>Philadelphia SEPTA</td>
<td>726</td>
<td>$63,079.3</td>
<td>15,458,068</td>
</tr>
<tr>
<td>Boston Old Colony Project (87)</td>
<td>90</td>
<td>$17,885.5</td>
<td>3,866,449</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Light rail systems</th>
<th>Total revenue vehicles</th>
<th>Tot. oper. expenses (000)</th>
<th>Vehicle revenue miles</th>
<th>Passenger miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Diego Trolley</td>
<td>24</td>
<td>$4,200.6</td>
<td>1,587,443</td>
<td>35,124,848</td>
</tr>
<tr>
<td>Newark NJT Corp.</td>
<td>26</td>
<td>$3,074.3</td>
<td>576,314</td>
<td>6,269,587</td>
</tr>
<tr>
<td>New Orleans RTA</td>
<td>35</td>
<td>$4,323.5</td>
<td>609,754</td>
<td>16,768,515</td>
</tr>
<tr>
<td>Cleveland RTA</td>
<td>48</td>
<td>$7,103.1</td>
<td>1,054,202</td>
<td>37,155,164</td>
</tr>
<tr>
<td>Pittsburgh PAT</td>
<td>87</td>
<td>$15,358.6</td>
<td>1,088,214</td>
<td>18,534,793</td>
</tr>
<tr>
<td>San Francisco MUNI</td>
<td>140</td>
<td>$29,815.0</td>
<td>4,001,576</td>
<td>140,340,497</td>
</tr>
<tr>
<td>Boston MBTA</td>
<td>229</td>
<td>$17,564.3</td>
<td>1,544,505</td>
<td>30,384,581</td>
</tr>
<tr>
<td>Philadelphia SEPTA</td>
<td>313</td>
<td>$37,960.3</td>
<td>5,559,584</td>
<td>108,088,997</td>
</tr>
<tr>
<td>Buffalo LRRT (76)</td>
<td>47</td>
<td>$4,620.0</td>
<td>6,250,000</td>
<td>88,320,000</td>
</tr>
<tr>
<td>Buffalo LRRT (87)</td>
<td>27</td>
<td>$11,555.0</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Santa Clara County LRT (86)</td>
<td>50</td>
<td>$8,786.0</td>
<td>2,727,300</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Sources: U.S. DOT, Annual Operating Statistics, Section 15, 1984
N/A: not available
<table>
<thead>
<tr>
<th>Commuter rail systems</th>
<th>Operating cost per revenue vehicle (000's)</th>
<th>Operating cost per revenue vehicle (000's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pittsburgh PAT</td>
<td>$160.3</td>
<td>$6.62</td>
</tr>
<tr>
<td>Detroit SEMTA</td>
<td>$81.3</td>
<td>$18.03</td>
</tr>
<tr>
<td>Chicago RTA</td>
<td>$190.4</td>
<td>$10.01</td>
</tr>
<tr>
<td>Newark NJT Corp.</td>
<td>$109.0</td>
<td>$4.78</td>
</tr>
<tr>
<td>Boston MBTA</td>
<td>$173.3</td>
<td>$6.23</td>
</tr>
<tr>
<td>Philadelphia SEPTA</td>
<td>$86.9</td>
<td>$4.08</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>$133.5</strong></td>
<td><strong>$8.29</strong></td>
</tr>
<tr>
<td><strong>St. Dev.</strong></td>
<td><strong>$42.9</strong></td>
<td><strong>$4.74</strong></td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td><strong>$81.3</strong></td>
<td><strong>$4.08</strong></td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td><strong>$190.4</strong></td>
<td><strong>$18.03</strong></td>
</tr>
<tr>
<td>Boston Old Colony Project (87)</td>
<td>$198.7</td>
<td>$6.62</td>
</tr>
<tr>
<td>Boston Old Colony Project (adjusted)</td>
<td>$186.7</td>
<td>$4.35</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Light rail systems</th>
<th>Operating cost per revenue vehicle ($000)</th>
<th>Operating cost per revenue vehicle ($000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Diego Trolley</td>
<td>$175.0</td>
<td>$0.12</td>
</tr>
<tr>
<td>Newark NJT Corp.</td>
<td>$118.2</td>
<td>$0.49</td>
</tr>
<tr>
<td>New Orleans RTA</td>
<td>$123.5</td>
<td>$0.26</td>
</tr>
<tr>
<td>Cleveland RTA</td>
<td>$148.0</td>
<td>$0.19</td>
</tr>
<tr>
<td>Pittsburgh PAT</td>
<td>$176.5</td>
<td>$0.83</td>
</tr>
<tr>
<td>San Francisco MUNI</td>
<td>$213.0</td>
<td>$0.21</td>
</tr>
<tr>
<td>Boston MBTA</td>
<td>$76.7</td>
<td>$0.58</td>
</tr>
<tr>
<td>Philadelphia SEPTA</td>
<td>$121.3</td>
<td>$0.35</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>$144.0</strong></td>
<td><strong>$0.38</strong></td>
</tr>
<tr>
<td><strong>St. Dev.</strong></td>
<td><strong>$40.2</strong></td>
<td><strong>$0.22</strong></td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td><strong>$76.7</strong></td>
<td><strong>$0.12</strong></td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td><strong>$213.0</strong></td>
<td><strong>$0.83</strong></td>
</tr>
<tr>
<td>Buffalo LRRT (76)</td>
<td>$98.3</td>
<td>$0.05</td>
</tr>
<tr>
<td>Buffalo LRRT (76, adj.)</td>
<td>$164.4</td>
<td>$0.08</td>
</tr>
<tr>
<td>Buffalo LRRT (87)</td>
<td>$428.0</td>
<td>N/A</td>
</tr>
<tr>
<td>Santa Clara LRT (86)</td>
<td>$175.7</td>
<td>N/A</td>
</tr>
<tr>
<td>Santa Clara LRT (86, adj.)</td>
<td>$169.0</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Sources:</strong> U.S. DOT, <em>ibid.</em> (1984), and own calculations.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.4. Difficulties and Issues

This section discusses those difficulties and issues that influence how the decision-making process is undertaken. They aid in understanding the reasons for some of the features of the process discussed in the previous section (that may prevent an attempt to carry out a process that follows the normative framework presented in section 5.2.2). These difficulties and issues have implications on how we must view the decision-making process and how we should devise ways to improve it (as will be discussed in chapter 6). Three major elements are included: the types of problems, the nature of information, and organizational issues.

5.4.1. Types of Problems

The literature on decision making highlights the differences between types of problems and the different responses they should require from decision makers. Ungson, et. al. [1981] discuss the issue of well-structured versus ill-structured problems and indicate that certain types of problems can be described as ill-structured due to (1) the ambiguity and incompleteness of the problem-related information, (2) the extent to which those problems are continually defined and redefined, (3) the lack of a clear program for the desired outcomes, (4) the possibility of influences from many actors or institutions, and (5) the extended period in which the decision is made.

The cost estimating process in transportation planning conforms largely to these characteristics. The case studies clearly illustrated that (1) it is hard to gather all the information necessary (at least at
the planning stage) for all the possible alternatives; (2) the scope of transit projects, affecting at the same time several communities and horizontal and vertical government layers, calls for a constant redefinition of the design characteristics of the alternatives; (3) the existence of many interested parties with a stake in the outcome of the process fosters the development of formal and informal influences and pressures; and (4) the development of a transit project, from its conception to final approval and implementation, may take more than a decade 202.

The ill-structured nature of the planning process -- and of its estimating component -- is compounded by the public nature of its context. Decision problems in public agencies are, in that regard, much more complex than in private organizations 203. This is the case because public agencies must weigh the decision in terms of some comprehensive system of public or community values (while private organizations are expected to take into consideration only those consequences of the decision which affect the organization alone).

Also, the decision maker cannot simplify the hypothetical conditions assumed to calculate the estimates, no matter how much this difficulty complicates the problem of selecting the "optimal" alternative, and cannot disregard conditioning facts or consequences simply because they fall

202 For instance, Buffalo's LRT took 16 years from initial plans to final construction. Santa Clara County's LRT took about the same period of time. Boston's initial proposals for the rehabilitation of the commuter rail line already started in the mid-1970s, although the formal proposals were not submitted to the state legislature until 1984.

203 Simon [1976], page 69.
outside the scope of a particular project or the decision-maker's interests. (For instance, economic conditions or citizens complains cannot be isolated from the process of planning and selecting the "optimal" transit alternative.) Further complications are introduced if more than one individual is involved, for in this case the stakes and decisions of the other individuals ought to be included among the conditions which decision makers must consider in reaching a decision. For instance, the cases illustrated the give-and-take nature of the funding process, whereby decisions along the process were reached after an iterative process between the different actors involved. This does not mean that a final -- mutually agreeable -- decision is always possible but that the process is complicated by the existence of several individuals with a stake in the outcome.

Decisions are also largely influenced by decision makers' perceptions of the problem and of the impact of the decisions on the relevant constituencies. In addition, decision makers develop impressions from their previous experiences and use them whenever they perceive they are applicable. It is in this context in which decision makers may be willing to obscure the kinds of alternatives available because they already have a solution in mind (as was largely the situation in the five case studies investigated in this thesis).

In these cases where the decision has already been made, independently of the analysts' work on the problem, a common and legitimate purpose of the analysis process is to justify decisions after they have already been

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204 This is in contrast to a purely scientific problem where the analyst/decision maker can chose to study only those consequences of the system he/she wishes to be concerned with.
made. However, this situation places a strong constraint on the analyst who should ensure that the analysis is honestly reported and that elements of it that might argue against what has been previously decided are not distorted or suppressed. This is hardly ever an easy situation.

5.4.2. Decision-Making and Information

In the light of the conditions indicated in the previous section, decision makers receive considerable amounts of information about the state of the world in addition to the purely technical one. This situation has led to the development of analytical decision aids as a way of easing the requirements over the decision-making process (with a tendency to focus on building models based on theories of rational choices). Inevitably, simplification becomes necessary and some sources of information receive more attention than others, depending upon the requirements for making the decision and the demands of the organizational/bureaucratic structure. The use of cost-effectiveness criteria responds to these needs and its simplicity. Yet, it is possible that the type of information the decision needs to focus on does not constitute the most convenient criteria.

This difficulty is usually present in those situations, as the one

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205 Mintzberg, et. al. [1976]. These authors stress the importance of paying attention to how individuals process information in organizational contexts, with particular emphasis on how their reactions to demands imposed by the organizational structure.

206 Ungson, et. al. [1981] indicate that the payback model in capital budgeting decisions has been used extensively in spite of the availability of better models. This is the case, they argue, because the time required to achieve satisfactory returns on investment may indeed be more accessible to a decision-maker's short-term "cognitive storage" than other criteria such as the present value of future income.
discussed in this thesis, in which a single attribute or dimension tends to dominate, but uncertainty -- and the ill-structured nature of the problem -- makes the choice difficult.

The relevance of information as the link between the different steps of the planning process is unavoidable and is one of the most powerful components. The difficulties of the decision-making process and how they are addressed influence decision makers' attitudes toward information. In turn, information affects those difficulties, closing a circle which can easily become a vicious one. Two main factors can make the activity of generating and acquiring information highly unreliable: (1) the failure to recognize its relevance in the decision-making process, and (2) its distorted generation. Both factors were present in the case studies as, respectively, (1) decision makers and analysts mostly viewed the planning process as a requirement to satisfy the needs of the bureaucratic structures and (2) the consistent underestimation of costs revealed.

Adams and Swanson [1976] discuss the issue of accuracy in the operations-management estimating process (e.g., PERT and CPM techniques) and indicate that uncontrollable factors (e.g., political delays, strikes) have a much smaller impact on accuracy than is generally believed. They indicate that accuracy is positively related to the amount of information. Furthermore, this amount is related to -- what they called -- decision maker talent and perception of the importance of accurate estimates. (These last two factors are, in turn, positively related to each other.) The authors conclude that formal feedback to inform the estimator about the accuracy of his estimates should be beneficial and that rewards can also help.
The importance of the estimate as perceived by the decision maker should determine his motivation and the amount of effort he is willing to spend in the search for accuracy. This perception is almost certain to be affected by a variety of conditions in the decision environment, such as the resources available to carry out the technical process, the possibility of being overburdened with information, or that information may become dysfunctional to the decision objectives (e.g., reach a compromise among several constituencies). These conditions are the ones that may sometimes lead to maintain -- or even increase -- uncertainty and, consequently, to increase the likelihood of generating inaccurate estimates.

5.4.3. Organizational Issues

Some organizational issues refer to the layout of the institutional framework, the responsibilities of each institution, and the consequent demands upon those institutions. In the case of Madrid, the central government backed the funding of the whole project and a "state-like" government agency was in charge of undertaking the planning process; in Boston, a metropolitan agency reporting to state legislature and the state Department of Transportation was in charge of leading the planning process while the federal government could possibly contribute funds to the construction of the selected alternative; in Buffalo, the involvement of the state was somewhat lower than in Boston (although, at the congressional level, the state representatives made a difference) and the federal government provided the largest percentage of funds for the construction of the LRRT system; in Santa Clara County, the involvement of the state was even lower (to the point of opposing the local initiatives) and the federal
government again covered most of the capital costs associated with the construction of the LRT line.

As was mentioned before, these different responsibilities create some difficulties in the technical process for it must respond to the requirements of the different audiences. But it also creates difficulties in the decision-making process. For instance, as the institutions have responsibilities over several geographical jurisdictions, the decision makers may have to try and provide some "jurisdictional" equity with the construction of the transit facility (as in the cases of Boston and Madrid where plans were geared towards areas that lacked the transportation infrastructure existing in other parts of the metropolitan areas). These organizational requirements, however, do not necessarily translate into the selection of the most cost-effective alternative, nor do they easily allow the design of alternatives involving an approach of incremental construction (that would permit more flexibility in allocating funds to cover capital costs).

Another organizational issue pertains to the role of the institutions in charge of carrying out the technical elements of cost estimating and the relationship among them and with the rest of the institutions involved in the broader planning process. Usually, the scale of the projects that are the subject of this thesis requires the involvement of several institutions and, mainly, of consultants outside the public transit agency. In the case of Boston, the technical studies were done by an outside consulting firm coordinating the efforts of several others consulting firms each one in charge of a different technical element. The transportation agency supervised the consultant's work. After the construction of the project by
contracting with other companies, the transit agency will be in charge of operating the new facility. The number of institutions involved creates some discontinuity in the process.

This discontinuity, however, is unavoidable as some institutions, e.g., the transit agencies, do not have the capability of carrying out the studies themselves. Each one needs the other. For instance, the consultant must get information from the transit agency to calculate some productivity values and particularly operating costs. Also, the organizational setting of assigning different teams of analysts different tasks, creates some mismatches.

5.4.4. Other Issues

Another issue in the decision-making process is the extent to which decision makers fully consider the consequences of their decisions. Some authors have examined specific ways in which the higher-level subsidies for transport projects (and transit operation) have distorted decision making, reduced efficiency, and increased costs. These authors state that, in the U.S., with large federal subsidies, state and local decision makers consider only the small portion of costs that they have to bear and thus tend to underestimate the full costs of transit projects. Subsidies also create an incentive to construct new systems, the benefits of which fall far short of total costs yet exceed local costs. Pucher [1988] asserts that countries where both decision making and financing are decentralized to the local of provincial level or government display considerably higher

\[207\] For instance, Pucher [1988]; Pickrell [1985]; Pucher, et. al. [1983]; Altshuler [1979]; and Hamer [1976].
productivity and lower unit costs than those countries where the central government plays the dominant role. For large transit projects, however, full decentralization may not be possible because regional or local institutions may lack the funds to construct those projects even if they are truly necessary. Some approach to internalization of costs in the decision is recommendable to force decision-makers to balance the consequences of their decisions to a greater extent and to promote sensitivity to the different needs and conditions of each area.

A final issue is that the project-planning process often goes from design to cost; in other words, first one decides what is wanted -- e.g., an LRT system -- and then one calculates how much it would cost to construct what is wanted (trying to find the lowest cost for the alternative selected). An alternative approach is "design-to-cost"; in other words, to select that project that best fits the resources available. Both approaches require a form of cost estimating. Neither would prevent underestimation. However, the emphasis changes. The latter approach is more difficult than the simple process of defining an alternative and estimating its cost because it requires an iterative process of defining-estimating-redefining-reestimating, and so on until the alternative can be accomplished with the funds allocated. It is also more difficult because the amount of resources available is seldom known in advance. On the positive side, a "design-to-cost" approach helps to internalize costs into the decision-making process, since, from the outset, decision makers are aware of the level of resources available.
5.5. Summary and Conclusions

This chapter has covered the issues of cost-estimating related to the decision-making process. After a brief discussion of decision making theory and the presentation of those particular characteristics that apply to the decision-making process in transportation planning, this chapter presented the decision-making context and how it can affect the cost-estimating process.

The importance of the decision criteria used to rate the alternatives, the need to acknowledge multiple perspectives involved in the process, and the difficulties that surround decision-makers' responsibilities illustrated the issues that frame the prevalent decision-making process. The way information is perceived by decision makers affects its use and how much effort is put into making it as accurate as possible. This creates a reinforcing circle where the difficulties decision-makers find in the process are affected by their attitudes towards information -- i.e., the results of the technical analysis --, attitudes that in themselves affect how the difficulties are overcome.

The next section puts all these elements together and those discussed in chapter 4 to generate a framework for the analysis of the cost estimating process in transportation planning and suggest some specific ways that attempt to address the difficulties and issues that prevent the achievement of a "better" decision-making process.
6. PUTTING THE PIECES TOGETHER:
A FRAMEWORK FOR COST ESTIMATING

6.1. The Interaction between the Technical and the Decision Making Processes

The discussion of the elements of the decision making process supports the thesis that, unlike other aspects of the human activity, such as scientific experiments, the technical analysis in transportation planning does not and cannot take place in isolation and is very much influenced by the decision-making process. Furthermore, the context within which the analysis takes place (and capital and operating costs are estimated) -- institutional/organizational setting, decision criteria, etc. -- affects the credibility, accuracy, and usefulness of that analysis (and of those estimates) in the planning and development stages of the project.

The assertion that the technical and decision making processes are not isolated but interconnected was strongly supported by the interviews undertaken with both analysts and decision makers involved in the cases presented in chapter 3. Individuals at all levels indicated how both processes feed each other, so that each can "learn" from the other. It is in this learning process as well that the processes influence each other that detaches them from a purely rational interpretation.

Four major dimensions can be singled out as influencing the interaction between the technical and decision-making processes: (a) the inherent limitations of the technical analysis, (b) the unstructured nature of the decision problem, (c) the organizational setting, and (d) the type of environment surrounding the transportation planning process.

(a) In the technical process, there exist limitations on how much can be accomplished and at which level of detail, due to both time and budget
constraints. At the stage of analyzing alternatives, many elements cannot be known with complete certainty (e.g., the underground conditions in the corridor, or the percentage of funds to be received from high-level institutions). The lack of certainty clears the way for the presence of ambiguity in both the design of the proposals and the objectives to be achieved with them. Ambiguity allows the different actors and, particularly, decision makers to portray their proposals as plausible means of achieving a set of specified objectives. Study constraints and uncertainty also force the type of analysis to become more a feasibility study (worthwhileness of any project among a specific set of projects, following a satisficing approach) rather than an optimization exercise (the selection of the best facility in terms of mode and size).

Moreover, in the technical process, the estimation of capital and operating costs involves a myriad of (cost) elements some of which almost everything is known about (e.g., the number of miles of track that must be provided between two particular points in the study corridor) while others are open to several design alternatives (e.g., the kind of station to be constructed at a particular point). In addition, some of them depend on other variables, namely the daily demand in the corridor, and therefore their design must be accommodated to the estimated values for those variables. Due to these types of variables, the process of estimating capital and operating costs fits the picture of a rather structured process (the techniques and steps are usually fairly specific and agreed upon) crowded with unstructured elements. Analysts must address these
elements through communication with the decision making process which, in principle, represents the link that channels the opinion of outside interested parties into the technical process. This link is delineated both formally through statutory regulations and informally through the stakes decision makers have in the process (e.g., reelection, yielding to pressures from interested parties, or just personal satisfaction).

(c) Both technical analysts and decision makers belong to organizations (even if these organizations have a congregation of one, i.e., themselves). The organizational structure of the technical analysis can affect the final outcome of the cost estimation process (and that of the planning process, in general). For instance, the interest in building a particular mode by the decision makers could encourage a stronger focus on that particular mode, with more resources assigned to the analysis of that mode and less detailed and specific examination of other alternatives. Furthermore, how the analysis fits the goals of the analysts’ and decision makers’ organizations and the incentives present to influence their behavior animate the presentation of the final results with its potential biases.

(d) Lastly, the type of environment surrounding the planning process affects where the emphasis would be put in the analysis process. For instance, the increasing attention to environmental impacts in the U.S. has taken away resources from other elements of the technical process, particularly cost estimation, and channeled them into the analysis of environmental concerns or the conduct of community hearings. To compound this situation, the fewer resources must
confront the additional requirements put on the cost estimation process generated by the increasing attention to environmental impacts. At a broader level, how the higher levels of government perceive their responsibilities in planning and funding public transportation projects further influences how the process is undertaken and for which reasons. For instance, in the U.S., the federal process, with its emphasis on cost-effectiveness measures, is seen by the applicants mostly as a bureaucratic hurdle that must be overcome to secure federal funding, not as a real opportunity to make the best decision.

6.2. General Framework

The four dimensions discussed in the previous section rest under the influence of a similar number of forces/actors: the environment, the analysts, the decision makers, and the funding institutions. The discussion of the role and stakes of these actors leads the way to the introduction, first, of the general framework, and, second, the analytical framework. The framework attempts to reconcile and account for the different perspectives on the transportation planning and decision-making processes examined in chapters 2 and 5. After the presentation of the analytical framework, this chapter also includes a discussion of how this framework would translate into operational actions.

Figure 6.1 shows a schematic representation of the general analytical framework.

The general framework identifies four major forces/actors in the planning and, particularly, cost estimation process: environment (in a
broader sense, encompassing from technical elements to interest groups, etc.), analysts, decision makers, and funding institutions. The fuzzy line separating analysts and decision makers, and the organizations they are part of, indicates that the separation is not clear cut but rather that communication exists between both sides. In fact, in some situations, the organization is the same, with open communication between analysts and decision makers. (For instance, in the case of Buffalo, the technical

Figure 6.1
General Framework

- Environment
  - Provider of information
  - Generator of problems ("needs")
  - Definition of scope
  - Constraints: institutional, technological, political

- Organization (Analytical)
  - What is at stake?
  - Constraints on level of detail
  - Constraints on technology
  - Organizational goals

- Analyst
  - Personal characteristics

- Organization (Decision-Making)
  - What is at stake?
  - Constraints from members
    - Organizational goals

- Decision maker
  - Personal characteristics

- Funding Institutions
  - Philosophy (goals)
  - Procedural requirements (thresholds)
analysis for the calculation of the operating costs was done in-house by members of the decision-makers' organization -- i.e., the Niagara Frontier Transportation Authority).

The environment provides information to the process. This information is in the form of problems (or "needs", being "needs" the perception of the problems by the actors who are part of the environment), resources (e.g., data to solve the "needs"), and constraints. Constraints come in the form of institutional constraints (e.g., legal constraints), political constraints (e.g., some proposals may not entail the necessary political appeal to ensure their implementation or may disproportionately and negatively affect some sectors of the population), or technological constraints (e.g., certain technologies cannot be applied to a particular corridor at reasonable costs due to topographical conditions).

How "needs" are defined affects the scope of the project and who will ultimately be affected and have a stake in the process. For instance, if the problem is regarded as congestion on a particular road and the "need" is perceived solely as relief of congestion, the (geographic) scope would be limited to the corridor in the vicinities of the road and probably those areas beyond, but close to, that road. If the problem however is defined as the need to relieve congestion on a road for the purposes of helping the construction of another major road in another section of the metropolitan area (like in the case of Boston), the scope is enlarged and the interested parties would include a much broader range of individuals, community groups, and institutions.

The environment encompasses three parties: the analysts, the decision makers, and the funding institutions. Each of these elements are
influenced by the environment and perceive that environment in different ways. In the end, what each party will try to do is to affect the vision of the other parties on the transportation problem (or "need") so that a common enough ground is laid out to proceed with the construction -- or not construction -- of a particular transit project.

The analyst belongs to an organization. This organization, a consultant firm or a transit operator, would constraint how the analyst acts by forcing him to perform in certain ways if he wants to stay in the organization 208. Constraints also exist on the level of detail of the analytical study. This level of detail depends, among other things, on how much is at stake for the analyst, the uncertainty associated with particular variables, the pressure generated by community concerns, and, indirectly, what the decision maker is asking for and how he perceives the technical process 209.

The decision maker also belongs to an organization. His beliefs will tend to support the status or enhancement of the organization through strategical and political gains, and at the same time achieve personal advancement 210. The members of the organization (as well as other individuals outside the organization) would also play their game and therefore constrain the maneuverability of the decision maker. In

208 Although this situation has not been present in any of the case studies, there have been other instances where analysts had to abandon the organization due to their disagreement with how the technical analysis was being undertaken. (See, for instance, the situation cited in Wachs [1985b], page 248.)

209 See also section 4.3.

210 Allison [1974] provides an explanation of a single event, i.e., the crisis generated by the installation of Russian missiles in Cuba, from the rational, personal, and political perspectives.
addition, the explicit and implicit organizational goals will also gravitate over the decision maker as he makes up his mind about a particular decision.

Analysts and decision makers have in addition some personal characteristics that would affect their individual behavior and the relationship between them. Their behavior would very much depend on how the analyst and the decision maker perceive what is at stake by following one or another course of action. For instance, the cognitive style of decision makers can vary from highly analytic to strongly heuristic. The former will look more at quantitative information, while the latter is interested in broader concepts and would make decisions based more on his intuition about how to solve the problem. Consequently, depending on the cognitive style, the decision maker would tend to influence more or less the analysis process or would trust more that process and let himself be influenced by it.

Finally, the funding institutions, also immersed within the environment, have a philosophy (or culture) that favors one or another type of reasoning as to how the technical analysis should be done, and the types of projects that should be undertaken and for which reasons. To accomplish these goals, these institutions establish some requirements for the technical process to follow, as well as thresholds that must be surpassed to prove the worthwhileness of the transit alternative so that this alternative can continue to be developed as specified in the bureaucratic (administrative) process towards its final implementation.

Based on this general framework and the four dimensions that influence the interaction between the technical and decision-making processes, four
main elements compose the analytical framework. First, as it relates to
the environment and the limitations of the technical analysis, the
uncertainty associated with the components of the general framework affects
the behavior and results of the process. Second, as it relates to the
analyst and the unstructured nature of the elements included in the transit
facility -- and of the goals to be addressed by that facility --, the
planning process is affected by technical problems (e.g., data collection
problems, limits on analytical techniques, etc.), and the definition of the
boundaries of the project (i.e., scale frames and scope of the project).
Third, as it relates to decisions made during the technical process and the
organizational setting, the final results (to be announced after the
technical process is completed) would likely be balanced against what is at
stake and the incentives analysts and decision makers have to favor or
discredit a particular course of action. Finally, as it relates to the
relation of both analysts and decision makers to the funding institutions
and the types of environments, the decision criteria influences which
variables and arguments are put forward and which have more possibilities
of being used as tools for hedging in the light of uncertainty.

6.3. Derivation of Analytical Framework

The next sections develop the four components of the analytical
framework at length. Each section includes: (a) description of the
component, (b) identification of the different types or elements of that
component, (c) discussion of the implications of the component for the
rational planning paradigm, and (d) review of the ways that component can
be influenced by specific actors involved in the transportation planning
6.3.1. Perspectives on uncertainty

Uncertainty can be defined as the attribute associated with something (e.g., the number of transit vehicles) that is subject to chance or change because its definition cannot be known in advance. Cost estimates are calculated based on either historical records or engineering estimation techniques. Each element has associated a level of uncertainty. The overall uncertainty of capital and operating costs comes from the uncertainty associated with each of the elements that influence the final calculation of those costs.

In chapter 4, the presentation of the technical cost estimation process -- summarized in figure 4.1 -- illustrated how the final capital costs depend on the level of demand whose value has associated a considerable level of uncertainty and that, in its turn, depends on other uncertain values such as the socio-economic characteristics of the region, technological advances, or even the tastes of the population. In the case of operating costs, demand also affects the uncertainty of the final figures, and so do productivity levels and the general behavior of the economy in the future (in terms of inflation, interest rates, etc.).

There are several ways to categorize uncertainty. For the

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There is a common distinction between descriptive and measurement uncertainty, the former being that related to which elements should be included, the latter being that related to how to measure the selected elements. Mahmassani [1984] categorizes uncertainty in five groups: (1) the unknown, (2) the occurrence of exogenous events, (3) the randomness in values of impacts, (4) the vagueness in definition of criteria, and (5) the uncertainty on which criteria and trade-offs we are going to use to decide among alternatives. Christensen [1985] classifies uncertainty in four groups depending on how much the actors...
purposes of the cost estimation process, uncertainty can be divided into three categories, according to the degree of avoidability of the uncertainty associated with a particular variable or component:

- **Inevitable** (or unavoidable) uncertainty relates to those variables, such as travel parameters (e.g., trips per capita) and, consequently, demand, or inflation, for which we cannot in advance know everything with complete certainty. There is nothing much the analyst can do about reducing this uncertainty except for acknowledging it and approaching it from a multiple-scenario perspective within which several plausible futures and different assumptions for each of these futures are developed.

- **Actionable** uncertainty relates to those variables for which we can, to some extent, improve the uncertainty of some of their components by "affording ground for an action." For instance, we could ideally set, regardless of demand, a price level to achieve some level of revenues. Or we could establish an operating plan for the proposed transit alternatives such that operating costs are kept to a certain level (within a more limited range of the uncertainty inevitably associated with these costs) and regardless of demand.

- **Avoidable** uncertainty relates to variables for which we can avoid the

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212 See Pearman [1988] for a description of methods of scenario construction suitable for transportation planning applications.
uncertainty related to the elements that influence that variable. For this last category we can distinguish between non-analytic (or negotiated) and analytic uncertainty. The former relates to variables like government and other funds for which we could, from the outset, know through negotiations or contracts what percentage of the capital and/or operating costs the transit operator would be able to secure. The latter relates to variables like productivity or unit costs for which we can, by collecting additional information, reduce uncertainty to an acceptable level. The tradeoff between how much time, effort (including political leverage), or resources we can spend on reducing the uncertainty related to these variables versus what we perceive we can gain from that reduction would determine how much the avoidable type of uncertainty would be reduced.

The classification illustrates that additional information can reduce uncertainty, but not impose certainty. (Moreover, how much the analyst can spend on acquiring additional information is always limited.) Also, decision makers may prefer to maintain uncertainty to some levels -- of the actionable or non-analytic types, in particular -- for the ambiguity created by the existence of uncertainty can give them the political leverage needed to reach compromise and negotiate with the different interested parties.\(^{213}\)

The classification further suggests that policies that aim to establish narrow criteria -- that is, criteria that focus on a small and very specific predefined set of variables and their values -- for the

purpose of accepting or rejecting projects may not be advisable. On one hand, narrow criteria can help reduce uncertainty as to what conditions a project must satisfy to gain final approval. On the other, if criteria are very narrow, problems may likely arise in terms of achieving cooperation and compromise, encompassing a variety of concerns, and avoiding biases. For instance, the surge of environmental issues in transportation planning has increased the uncertainty and ambiguity of the process but, on the other hand, has provided the opportunity that allows the dialogue and the building of constituencies, bringing together people with different wishes and political interests. A criteria for evaluation purposes based on cost-effectiveness measures cannot easily incorporate these issues and would reduce the possibilities of a productive dialogue. This suggestion does not provide a clear indication of which range of criteria should be used and when those criteria are sufficiently wide to prevent biases and encompass the variety of concerns. Nevertheless, it further suggests that the planning process will have to put more emphasis on the basis upon which each individual project would be evaluated rather than to establish, from the outset, a unique yardstick for all them.

6.3.2. The Planning Environment (Technical Issues)

The technical process has other determinants, besides the inherent uncertainty of the variables, that create additional difficulties in accurately estimating the capital and operating costs of a transit

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214 In the U.S. cases, participants complained about the federal emphasis on cost-effectiveness criteria indicating that those criteria reflect a narrow focus -- some said "East-Coast mentality" -- as they cannot incorporate concerns that vary widely from some regions of the country to others.
facility. Two of them are the effects of the perspectives of the actors involved in the process and the effects of the information gathering and manipulation activities. (Chapter 4 highlighted and discussed other difficulties and issues related to the attempt, in the analysis process, of achieving more accurate cost estimates.)

The first determinant affects the coordination between what the technical process is trying to address and the broader social and political environment. For instance, the decision maker must pay attention to other perspectives in addition to the rational-technical process, such as the socio-political environment and the organizational conditions. The pace of these broader processes -- i.e., how fast events related to these processes occur -- would likely differ from that of the technical process. If this process goes behind the broader processes, it would become sidetracked and used just as a justification to the decisions made largely outside the technical sphere.

The second determinant involves a methodological question. Costing methodology is simple, but lengthy, particularly for operating costs. Changes may require to look back at a whole series of operating strategies, productivity assumptions, and unit cost measures. If for whatever reasons the cost of the project changes along the way, the technical process may be unable to incorporate those changes and become outdated. This conflict arises from the frequently static nature of the technical process and the dynamism of the environment surrounding it. When that happens, the length of the process and the resources already spent create a drag (for political and emotional reasons) that easily prevents efforts to reconsider major components of the analytical study.
Time and Scale Frames (project scope)

Analysts, decision makers, and funding institutions have different time frames, scale frames, and overall perspectives. As to time frames, some focus on the short term (e.g., the benefits in the first ten years after the construction of the facility are very limited and the operating costs very high, hence the system is not good), others in the long term (e.g., the benefits will accrue as changes in land use will improve the conditions of the city core, revitalizing it and restoring its centrality). As to scale frames, some focus on small scale effects (e.g., the system will improve my trip time downtown), others focus on a larger scale (e.g., the system will bring people from outside counties into downtown). As to overall perspectives, the higher-level institutions may contend that their role relates more to balancing the national budget and transit projects do not fall within those concerns since those kind of projects are geared to addressing local problems; the regional institutions may contend that cities are strong elements of the national economy and therefore the higher-level institutions should contribute to the construction of large projects that can help improve environmental conditions and reduce energy consumption; and local governments may contend that by themselves they are unable to undertake such large investments although they must provide for the needs of its citizens (and in addition bring jobs and higher-level funds, if possible).

These different frames affect the technical analysis because the inevitable large number of interested parties makes harder for that analysis to address all the issues that may be raised, and because decision makers need to account for all the concerns. The case studies clearly
indicate how changes in the final costs are, in a sizeable percentage, due to additions or changes in the design of the system. In some cases, some important components of capital costs were put back and forth along the process (e.g., the case of La Salle station in Buffalo). As the process unfolds, community groups perceive the project with a different interest while the analyst/decision-maker must twist their assumptions to sort out or fit the demands of most parties (community and funding institutions).

The different frames have led to the consideration of a broad set of variables. In the U.S., a large proportion of the study resources must be dedicated to environmental issues, and not so much on costs. For instance, in the case of Boston, 19 reports were published, with only two directly related to capital and operating costs. Costs are however an important element for funding institutions and eventually a major concern after the system is constructed. Once the system is in place, the affected parties can get used to noise or vibration (up to a certain limits) but not to taxes and cost overruns or operating deficits.

Information Systems

The technical process requires large amounts of (cost) data. Some data can be found cheaply and quickly, and with low uncertainty (e.g., the cost of a light rail vehicle), while other data are hard to find, and even if found it has associated a high level of uncertainty (e.g., underground conditions, or labor costs). Furthermore, once data are organized and stored, the dynamism of the process requires an adequate design of an information process that allows the easy maintenance and update of (cost) data.

The dynamism of the information is hardly recognized, and makes harder
to address the concerns raised in the previous section (about changes in
the scope of the process) and limits the potential use of information not
only as a decision-support tool but also as a negotiation-argumentation
instrument promoting the dialogue among conflicting views. The case
studies clearly illustrate the limited role of information as merely a tool
for accountability (data bank) and its design as a way to take advantage of
the economies of handling of mathematical operations (routines).

One of the major reasons indicated for the limited role of data as a
decision-support tool is the perception that data lack generality, being
created and manipulated for such a particular case that it does not deserve
to be expanded to achieve a role broader than accountability. This view
prevents the implementation of more powerful, flexible, and dynamic
information systems. Moreover, the cost of establishing and maintaining
large data banks are perceived to be too expensive in the light of its
perceived subsequent low use in the planning process.

These perceptions largely originate in a rationalist view of the
process. The recognition of the limits of this rationalist perspective
would help to recognize that, as Klosterman [1987] indicates, the
information can become "a focus for political dispute, negotiation and
bargaining as participants in the modelling process resolve fundamentally
political questions of identifying the most appropriate data, assumptions,
and results." This approach, however, must be undertaken trying to avoid
endless discussions over minor elements of the technical process 215, and
instead foster the discussion of assumptions, methods, and facts that

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215 The case of La Paz, Bolivia, illustrates how a process can become
bogged down to the discussion of which overall capital costs should be
used as input to the financial analysis model.
underlie conflicting perspectives on the transit project.

6.3.3. A Decision Model for Cost Underestimation

The past two sections discussed those components of the framework upon which analysts or the decision makers can act from a technical perspective (e.g., by reducing uncertainty, developing an information system, etc.). In this section, the behavior of analysts or decision makers, as they ponder what to do in the light of their personal goals, the probabilities of achieving them, and their stakes in the process, is explicitly incorporated. Through the use of decision analysis tools and the development of a decision model for cost underestimation, this section helps understand the interrelationships between the different decisions that can be made about the study and how probable underestimation can be.

The decision process regarding the choice of analysis method (not the one related to which alternative to pursue, but to how to carry out the technical analysis and which costs to announce) can be thought of as the following: a decision maker wishes to get a particular transit project approved for particular reasons (e.g., a vision of how the region should grow, political gains or just personal satisfaction). To do that he hires a consultant (analyst) who specializes in that kind of project (and particularly in calculating costs). Because he wishes to avoid the burden (emotional and monetary costs) involved in carrying out and submitting a study that will not be approved, the decision maker tells the analyst to inform him of the progress of his findings before making an announcement of the technical study. The consultant's previous experience indicates that his prediction is correct a given percent of the times (for those cases
when the project is constructed).

In this situation, there are four major components in the cost estimation process: (a) how much the consultant believes the facility is going to cost after performing the technical calculations (the consultant’s best guess); (b) how much the consultant (or decision maker) says the facility is going to cost (regardless of what the consultant believes it is going to cost); (c) how likely it is that the facility will be constructed; and (d) how much the facility ends up costing.

Those four components are not independent but interrelated. How likely it is that the facility will be constructed depends on how much the facility is expected to cost. We can assume that the likelihood of the construction depends solely on some specific criteria -- e.g., a cost-effectiveness index or some other general criteria -- established by a higher level institution (the funding institution). Approval of the project, however, is not deterministic but probabilistic for, although the project may or may not meet those criteria, the construction is not automatically accepted or rejected but rather depends on many other factors and particularly on how close the project falls to meet those criteria.²¹⁶

The final costs of the facility do not depend on what the consultant says the facility is going to cost; it depends on the initial design and other factors such as community concerns, legal disputes, construction

²¹⁶ This assumption resembles the U.S. context where, although criteria have been established for approving or rejecting transit projects, the possibilities of getting the approval is much broader than those established by the criteria and depend on many other political, institutional, and economic factors. Some probabilities can then be assigned to each expected cost. In other countries, formal criteria do not usually exist, but we can assume that implicitly costs or some cost-related thresholds have some effect of the decisions of the higher level institution.
management expertise, and the like. What the consultant says does not alter the cost probabilities of the facility, but they are correlated because the consultant is knowledgeable (i.e., the consultant's accuracy for the particular type of facility). The correlation between these two probabilities -- consultant's accuracy and the final costs of the facility -- allows one to calculate the conditional probabilities of how much the project ends up costing given the consultant's estimates, based on consultant's record of accuracy (i.e., conditional probability of being correct given the final cost of the facility).

Finally, the consultant is influenced in what he says the facility is going to cost by his/her preferences (expected utility) for likely consequences of his/her report (as well as his/her desire to forecast accurately). The expected utility would for instance depend on how likely it is that the facility will be constructed or on how much is at stake by not being accurate and how the consultant (or the decision maker) feels about the consequences of disclosing one cost or another. Incorporating expected utilities into the model adds another component to it, for by investigating the effect of penalizing or rewarding one of the actions -- e.g., under-estimation --, we can perceive the possibilities of influencing the consultant's (or decision maker's) decisions about what cost to disclose.

Although the model does not incorporate actual utility values, the case studies clearly support the assumptions taken in the development of the model. First, most of the actors involved in the analytical process strongly favored the construction of the prefered alternative (versus no construction) and felt that if funds were not ensured the project would
have never been constructed. Second, the length of the process and the perseverance of the interested parties further support utilities that are higher for those outcomes that result, ceteris paribus, in the construction of the project. Second, the fact that changes that ultimately affected the accuracy of the estimates were mostly changes related to the scope of the project, indicates that analysts usually make their best at calculating the right costs and would always prefer to be right (i.e., generate the correct estimates) than to be wrong (i.e., underestimate or overestimate).

Finally, combining the last two, the actors should usually prefer to be on target (i.e., be accurate) and, in addition, see the project constructed. (What is more difficult to know is how much these utilities vary from one set of conditions to another. However, this does not affect the conclusions of the model if changes in the initial conditions -- with different sets of utility values -- yield similar (and consistent) conclusions.)

With these relationships and assumptions the model tries to incorporate the consultant’s analytical capacity -- i.e., how good the estimates are -- coupled with the possibilities of biasing the results -- not necessarily by selecting the wrong costs or manipulating the results but by selecting optimistic values or minimum standards -- so that the transportation facility gets approved and constructed. The output of the model gives us an indication of how often and under what conditions the consultant (or decision maker) may bias the results by publishing a cost that is under or above the one actually estimated.

With the description of the components, we can now formally develop the different decision steps and the decision model from the perspective of
the consultant (and decision maker) 217:

1. Initially there is an unconditional probability for a given type of project (e.g., an LRT line at grade). The cost of this type of project has some probability distribution, which we assume to be discrete and symmetrical with a low, a medium, and a high value 218. These probabilities are called P(A), P(B), and P(C), or the probability of a low cost, medium cost, and high cost respectively. For instance, unconditional (prior) probabilities (for a given project) could be 50% for a middle value, with 25% for a low and a high value. In other words:

   \[
   P(A) = 25\% \quad P(B) = 50\% \quad P(C) = 25\%
   \]

2. The consultant has a record of accuracy associated with similar types of projects. This accuracy comes not only from the consultant’s analytical capabilities but also from how much time and money is spent on calculating costs and generating more detailed analyses of costs (reducing analytical uncertainty) by gathering additional information on unit costs, quantities, and productivities. These are conditional probabilities, such as P(α/A) or probability that the consultant estimates that the cost is A given that the cost is actually A. If the consultant is correct 80% of the times, this probability -- P(α/A) 219

217 By taking the analyst/decision maker perspective, we assume that the consultant and the decision maker(s) are working in the planning of the facility whereby the consultant makes the calculations and together the consultant and the decision maker announced how much the facility will cost. The role of the decision maker is important since he would probably be the actor with the greatest interest in the construction of the facility.

218 The approach can be easily expanded to include many more values, or a continuous probability distribution. These extensions are not necessary for the purposes of the exercise developed in this thesis.
will be 80%. For instance, the accuracy of the consultant could be as follows:

Correct: \[ P(\alpha/A) = P(\beta/B) = P(\tau/C) = 80\% \]
Underestimate: \[ P(\alpha/B) = P(\alpha/C) = P(\beta/C) = 10\% \]
Overestimate: \[ P(\beta/A) = P(\tau/A) = P(\tau/B) = 10\% \]

3. We must also assume some probabilities for the construction of the project, depending on how much the project is expected to cost. These are therefore conditional probabilities (e.g., probability of the project being constructed given that the (disclosed) expected cost is low). For instance, a whole set of probabilities of construction would be:

\[
\begin{align*}
P(\text{yes}/A) &= 100\% \\
P(\text{yes}/B) &= 50\% \\
P(\text{yes}/C) &= 25\% \\
P(\text{no}/A) &= 0\% \\
P(\text{no}/B) &= 50\% \\
P(\text{no}/C) &= 75\%
\end{align*}
\]

4. Finally, each outcome from the decision tree, in terms of the construction or no construction of the facility and the accurate or inaccurate estimation of the costs, has an associated utility (for the consultant and/or decision-maker). These utilities can be derived by pairwise comparison of every two outcomes, the ranking of the outcomes, and the calculation of a consistency index to check that the pairwise comparisons do not contradict each other.\(^{219}\). Each set of rankings and expected utilities indicate a hypothesis about the wishes of the consultant and/or decision-maker or the rewards and penalties

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\(^{219}\) Saaty [1980] explains a methodology to develop a ranking of alternatives based on pairwise comparisons. The methodology is based on the perceptions of the decision maker (or group of decision makers), and hence incorporates more than just quantitative values (in fact, judgments can be verbally expressed). Through the use of eigenvalues -- i.e., the solutions to a particular type of matrices such as \[ A \mathbf{w} = n \mathbf{w} \], where \( A \) are the relative weights obtained through pairwise comparison and \( \mathbf{w} \) is the vector of individual weights -- we can derive the ranking of activities and their relative weights.
that each outcome would cause the consultant and/or decision-maker (e.g., if underestimation is penalized with less funds for the project, outcomes that involved underestimation would have a much lower utility). For instance, the next table shows the utilities in the case that the highest utilities are perceived when the project gets built and the estimates are accurate, while the lowest utilities are perceived when the project does not get built (with lowest utility when cost is expected low, and highest when cost is expected high). In between, utilities are higher when the project gets built but overestimation occurs, and lower when the project gets built and underestimation occurs. Utilities have been valued between 1.0 and 0.0 without loss of generality. (See next paragraph for additional interpretation of utility values.)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Ranking</th>
<th>Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected A, gets built, and costs A (AGA)</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>Expected B, gets built, and costs B (BGB)</td>
<td>2</td>
<td>0.95</td>
</tr>
<tr>
<td>Expected C, gets built, and costs C (CGC)</td>
<td>2</td>
<td>0.95</td>
</tr>
<tr>
<td>Expected B, gets built, and costs A (BGA)</td>
<td>4</td>
<td>0.90</td>
</tr>
<tr>
<td>Expected C, gets built, and costs A (CGA)</td>
<td>5</td>
<td>0.85</td>
</tr>
<tr>
<td>Expected C, gets built, and costs B (CGB)</td>
<td>6</td>
<td>0.80</td>
</tr>
<tr>
<td>Expected A, gets built, and costs B (AGB)</td>
<td>7</td>
<td>0.70</td>
</tr>
<tr>
<td>Expected B, gets built, and costs C (BGC)</td>
<td>8</td>
<td>0.65</td>
</tr>
<tr>
<td>Expected A, gets built, and costs C (AGC)</td>
<td>9</td>
<td>0.50</td>
</tr>
<tr>
<td>Expected C, and does not get built (CnG)</td>
<td>10</td>
<td>0.40</td>
</tr>
<tr>
<td>Expected B, and does not get built (BnG)</td>
<td>11</td>
<td>0.25</td>
</tr>
<tr>
<td>Expected A, and does not get built (AnG)</td>
<td>12</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Note: A is the low cost, B the medium cost, and C the high cost. Outcomes AGA, BGB, and CGC indicate accurate estimates; outcomes BCA, CGA, and CGB indicate overestimation; and outcomes AGB, BGC, and AGC indicate underestimation.
For a probabilistic interpretation of the utility values, we must refer to the concept of certainty equivalent \(^{220}\). A certainty equivalent of a probabilistic outcome is the utility at which the decision maker is indifferent between that probabilistic outcome and that utility for a certain outcome. In the case of this chapter, this certainty equivalent could be calculated by first specifying the most and the least preferred alternatives (and assigning utilities of 1 and 0, respectively) and then asking the analyst (or decision maker) at which point he/she would feel indifferent between a particular outcome (say CGA) and a lottery with probability \( p \) at best outcome (i.e., AGA) versus probability \( 1-p \) at worst outcome (i.e., AnG). In the case shown in the previous page, the analyst feels indifferent between outcome CGA and a 85% probability of AGA and a 15% (i.e., one minus 85%) of AnG. \(^{221}\)

On the basis of the four sets of information (i.e., unconditional probability for a given type of project, consultant's conditional probabilities, conditional probabilities for the construction of the

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\(^{220}\) Keeney and Raiffa [1976], chapters 4 and 5.

\(^{221}\) Actually, this is a case of a two-attribute utility function. The two attributes are: accuracy (discrete with three values: accurate, over, or under) and building the facility (discrete with two values: is/is not built). The two attributes are not independent since how the decision maker (or analyst) feels about accuracy depends on the construction of the facility (and the final cost of the facility which is correlated to his/her accuracy). Conversely, analyst's utility from the construction of the facility depends on his/her accuracy in predicting the final cost. Based on these concepts, the utility can be probabilistically interpreted as the point at which the analyst (or decision maker) feels indifferent between a particular outcome and the lottery with \( p \) of getting the best outcome versus \( 1-p \) chances of getting the worst outcome. In this section, through the consideration of three cases (the last one, assuming independence between the two attributes), results should be general enough to reach convincing conclusions and test the validity of the model.
facility, and analyst's or decision maker's set of utilities) we can now
generate a decision tree and compute other conditional probabilities. To
begin with, we need to know what the probabilities are that the project
costs an amount -- e.g., low -- given that the consultant has said that the
project will cost another amount -- e.g., medium. In other words, we are
looking for $P(A/\alpha)$. To calculate these values, we can apply Bayes theorem.
This theorem indicates that:

$$P(X/Y) = \frac{P(X \& Y)}{P(Y)}$$

Therefore, in our case,

$$P(A/\alpha) = \frac{P(A \& \alpha)}{P(\alpha)}$$

We must then calculate the joint probabilities, and from them the
unconditional probabilities. This is an example:

<table>
<thead>
<tr>
<th>Prior prob.</th>
<th>Consultant's accuracy</th>
<th>Joint probabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 25% - $\alpha$ 80% ==&gt; A &amp; $\alpha$ 20.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B 50% - $\beta$ 80% ==&gt; B &amp; $\beta$ 40.0%</td>
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<tr>
<td>C 25% - $\tau$ 80% ==&gt; C &amp; $\tau$ 20.0%</td>
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</table>
Then, the unconditional probabilities are:

\[ P(\alpha) = 27.5\% \quad P(B) = 45.0\% \quad P(\tau) = 27.5\% \]

And the conditional probabilities will be:

\[
\begin{align*}
P(A/\alpha) &= 72.7\% \\
P(B/\alpha) &= 18.2\% \\
P(C/\alpha) &= 9.1\%
\end{align*}
\]
\[
\begin{align*}
P(A/B) &= 5.6\% \\
P(B/B) &= 88.9\% \\
P(C/B) &= 5.6\%
\end{align*}
\]
\[
\begin{align*}
P(A/\tau) &= 9.1\% \\
P(B/\tau) &= 18.2\% \\
P(C/\tau) &= 72.7\%
\end{align*}
\]

Based on these values and the expected utilities for each outcome, we can develop the full decision tree. This is shown on the next page. The numbers (in bold face) next to what the consultant says the project will cost -- i.e., \(A\), \(B\), and \(C\) -- are the expected utilities of each decision. Based on these utilities the consultant/decision-maker will announce one or another cost, resulting in the underestimation, accurate calculation, or overestimation of the cost values.

In this particular example, the consultant/decision-maker will select \(A\) as the cost to be announced all the time since that option is the one that yields the highest expected utility in all the three branches of the decision tree. By changing the initial conditions and assumptions, we can now investigate what this decision model tells us about the underestimation of costs.

We can establish a baseline case with the assumption that the consultant is accurate all the time and that the project is always constructed (regardless of its expected costs), and that the prior probabilities and utility distribution are the one assumed in the previous example. In this situation, the results will never be biased and the consultant will always announce the costs that he has calculated through the technical process.

In addition, the total combined utility is the highest, around 0.96.
This overall utility is obtained by multiplying the (unconditional) probabilities of what the consultant has estimated the project is going to cost by the utility of each selected outcome in each branch of the decision tree. In other words,

\[
\text{Overall utility} = P(\alpha) \times \text{max.util.}[(A, B, C) \text{ in } \alpha \text{ branch}] + \\
+ P(\beta) \times \text{max.util.}[(A, B, C) \text{ in } \beta \text{ branch}] + \\
+ P(\tau) \times \text{max.util.}[(A, B, C) \text{ in } \tau \text{ branch}]
\]

When all the possible outcomes report a utility of 1.0, the probability of construction is 100% regardless of estimated costs, and the consultant is accurate all the time, the overall utility would yield a value of 1.0. Deviations from that situation, because outcome utilities are lower than 1.0, or because the probability of construction is lower than 100% for some of the costs, or because the consultant is not accurate all the time, would yield overall utilities lower than 1.0. Therefore, this overall utility gives an indication of how far we are from an "ideal" situation where utilities have maximum values and probabilities for construction and accuracy are 100%.

By changing the initial values for the consultant's accuracy and the probability of construction, but keeping the same utility distribution, we can obtain the results on the next table.

These results indicate that when the consultant's accuracy increases there is, in general, a tendency to select the estimated costs, that is, not to generate any bias. When the differences in construction probabilities among the three outcomes is low, however, there is a tendency to overestimate costs (for instance, the case where the three construction probabilities are 50%). This is mainly because, for the particular set of
<table>
<thead>
<tr>
<th>What cons. thinks it will cost</th>
<th>What consult. says it costs constructed?</th>
<th>How much it ends up costing</th>
<th>Outcome Utility</th>
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<tbody>
<tr>
<td></td>
<td>/ A 72.7% AGA 1.00</td>
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<td></td>
<td>Yes 100% - B 18.2% AGB 0.70</td>
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<td>/ C 9.1% AGC 0.50</td>
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<td>A 0.90 \ No 0% - 100.0% AnG 0.00</td>
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<td>/ A 72.7% BGA 0.90</td>
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<td>C 0.57 \ No 50% - 100.0% BnG 0.25</td>
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<td>/ A 72.7% CGA 0.85</td>
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<td>A 0.71 \ No 0% - 100.0% AnG 0.00</td>
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<td>/ A 5.6% BGA 0.90</td>
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<td>Yes 50% - B 88.9% BGB 0.95</td>
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<td>/ C 5.6% BGC 0.65</td>
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<td>C 0.51 \ No 75% - 100.0% CnG 0.40</td>
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<td>/ A 9.1% CGA 0.85</td>
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<td>Yes 25% - B 18.2% CGB 0.80</td>
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<td>C 0.53 \ No 75% - 100.0% CnG 0.40</td>
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utilities selected for this example overestimation reports higher utility than underestimation. (This is a questionable alternative but falls on the conservative side and supports the main conclusions.)

In addition, the model indicates that when the construction probabilities are sufficiently reduced for expensive projects, underestimation is the most likely outcome. For instance, the case where the probability of construction is 40% for A and 0% for the other two costs, there is a tendency to overestimate. However, when the probability increases to 80% for A but stays at 0% for the B and C, there is a tendency to underestimate.

For a given accuracy level, it can be shown that underestimation begins as soon as there is a sufficiently large differential between the probabilities of construction between the lowest and the medium and highest cost values. For instance, for a 100% consultant’s accuracy, when the probability of construction for A is 100%, underestimation will take place if the probability of construction for B or C is lower than 64%. When the probability of construction for the lowest cost decreases, the differential at which underestimation begins augments, indicating that if construction is less likely, the willingness to underestimate -- for the set of utilities assumed in this case -- is reduced.

We can now assume a different set of expected utilities. For instance, we can assume that utility is still high if estimates are correct, but low if they are overestimated (the consultant may feel bad to be above the mark, lowering the possibilities of getting funds for the project). If underestimation is small, then utility is fairly high and lower the larger the underestimation is (the consultant may feel bad to
<table>
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<tr>
<th>Consultant's accuracy</th>
<th>Probability of construction</th>
<th>Cost selected</th>
<th>Overall utility</th>
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underestimate by a wide margin). Utilities for no construction are higher than in the previous case when the consultant selects the high or medium

---

222 This percentage would ideally correspond to the accuracy that would be obtained by random choice.
values (he/she may feel that with high or medium costs, no construction is expected and therefore he is not so disappointed if the project is not constructed) and zero again if the lowest cost is selected. The following table shows this set of utilities.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Ranking</th>
<th>Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGA</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>BGB</td>
<td>2</td>
<td>0.95</td>
</tr>
<tr>
<td>CGC</td>
<td>4</td>
<td>0.90</td>
</tr>
<tr>
<td>BGA</td>
<td>9</td>
<td>0.30</td>
</tr>
<tr>
<td>CGA</td>
<td>11</td>
<td>0.10</td>
</tr>
<tr>
<td>CGB</td>
<td>7</td>
<td>0.40</td>
</tr>
<tr>
<td>AGB</td>
<td>2</td>
<td>0.95</td>
</tr>
<tr>
<td>BGC</td>
<td>5</td>
<td>0.80</td>
</tr>
<tr>
<td>AGC</td>
<td>7</td>
<td>0.40</td>
</tr>
<tr>
<td>CnG</td>
<td>6</td>
<td>0.50</td>
</tr>
<tr>
<td>BnG</td>
<td>9</td>
<td>0.30</td>
</tr>
<tr>
<td>AnG</td>
<td>12</td>
<td>0.00</td>
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</tbody>
</table>

With this new utility distribution (and assuming the same prior probabilities), the results are the ones shown in the next page.

These results indicate that, once again, when consultant’s accuracy increases the tendency is towards less bias of costs. But now when accuracy decreases there exists a stronger tendency to underestimate, compared to the previous example (since overestimation does not report high utilities anymore). When the probabilities of construction are high for the lower costs (i.e., close to the 100% certainty), the consultant will again tend to underestimate costs. On the other hand, when the probabilities are very small for the higher costs but high for the low costs (e.g., the case of 53% for A, and 0% for B and C), the consultant will tend to overestimate costs in spite of the probability differential (because he/she does not feel so disappointed when construction does not take place due to the announcement of high costs). For the set of utilities of this case,
the differential at which underestimation begins decreases with the
decrease in the probability of construction for the lowest cost. Finally,
when the construction probabilities are similar for all the costs, the
consultant will tend to bias the cost estimates less often (i.e., the cases
where the probabilities are 67%, 50%, and 40% for A, B, and C respectively.

<table>
<thead>
<tr>
<th>Consultant's accuracy</th>
<th>Probability of construction</th>
<th>Cost selected</th>
<th>Overall utility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
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or 50% for the three costs).

Still assuming another set of utilities, we can run another simulation considering that utility is highest (i.e., 1.0) whenever the consultant is accurate, two-thirds (i.e., 0.67) whenever he overestimates the cost, one-third in the case of underestimation, and zero if the project is not constructed.

<table>
<thead>
<tr>
<th>Outcome Ranking Utility</th>
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</thead>
<tbody>
<tr>
<td>AGA 1 1.00</td>
</tr>
<tr>
<td>BGB 1 1.00</td>
</tr>
<tr>
<td>CGC 1 1.00</td>
</tr>
<tr>
<td>BGA 4 0.67</td>
</tr>
<tr>
<td>CGA 4 0.67</td>
</tr>
<tr>
<td>CGB 4 0.67</td>
</tr>
<tr>
<td>AGB 7 0.33</td>
</tr>
<tr>
<td>BGC 7 0.33</td>
</tr>
<tr>
<td>AGC 7 0.33</td>
</tr>
<tr>
<td>CnG 10 0.00</td>
</tr>
<tr>
<td>BnG 10 0.00</td>
</tr>
<tr>
<td>AnG 10 0.00</td>
</tr>
</tbody>
</table>

With these utilities, the results of the model are the ones shown in the next page.

In this situation, where underestimation is heavily penalized while accuracy is rewarded, and the consultant (or the decision maker) gets no utility from the cancelation of the project, there is a tendency to underestimate the costs when there is a sufficiently large differential between the probabilities of construction for the medium and high cost alternatives compared to the low cost alternative (see, for instance, the case where probabilities are 50% for A, and 0% for the other two costs). On the other hand, when the probabilities are similar across the different
options, the consultant will tend to be accurate, and less so -- with a tendency to underestimate --, when his overall accuracy decreases.

Consultant's accuracy, once again, tends to favor unbiasing the results.
Summarizing, the model indicates the following conclusions:

a. The concern for securing the construction of the facility has a significant impact on the possibilities that the results will be biased. If higher cost estimates reduce the likelihood of the transit facility being built, then the consultant will tend to shift estimates to be biased low (assuming the bias is not detectable as "deliberate").

b. If the project is constructed regardless of how much the consultant says it is going to cost (i.e., the funding institution assures the project will be constructed, or earmarked funds are created for the construction of the facility), underestimation is unlikely.

c. Underestimation will more likely take place when there is a sufficiently large differential between the probability of construction for the lowest cost and the medium and high costs. This differential tends to increase or decrease (hence, underestimation will be less or more likely) -- as shown in the first two cases -- depending on the probability of construction for the lowest cost and how the consultant (or decision maker) feels about the benefits of underestimation (as reflected in the assumed set of utilities).

d. The higher the consultant's accuracy, the more likely he will announce the actual estimates, and the lower the tendency to bias the results.

e. How the consultant (or decision maker, depending on who is in charge of announcing the results) perceives the utility of the consequences of underestimation, overestimation, and the no construction of the facility largely affects the likelihood of biasing the results. By penalizing underestimation and rewarding accuracy, the consultant will
tend to select the estimated costs, and not to bias the results.

One conclusion illustrates that when the consultant reduces the uncertainty of the cost estimates (i.e., the consultant’s accuracy is closer to 100%), underestimation is less likely. An explanation for this result is that, when accuracy is high, the consultant have less tendency to bias the results, because his/her utility normally decreases when the disclosed costs are well off the final construction costs. Another conclusion illustrates that if the decision to build the facility is certain from the outset, underestimation is less likely. (Of course, avoiding the bias of the (disclosed) costs may likely not be the only purpose of the high-level institution as this institution makes a decision about the construction of the facility.)

The model further exemplifies how uncertainty allows ambiguity and the possibility of biasing the results, and how the technical analysis can be distorted by the interests that take place in the decision-making process. Furthermore, the incentives from the funding institutions can play a major role in adjusting the behavior of the analyst/decision maker to proceed with more "unbiased" procedures.

6.3.4. Decision Criteria

Analysts and decision makers are not the only actors in the process. The funding institutions also have a role, must make decisions about which project to fund, and have other competing interests gravitating over them. To make their decisions, these institutions must develop mechanisms for evaluating each project against other proposals for funding (i.e., other transit projects). The many components and variables of large transit
projects create an intricate and laborious task. Therefore, in order to address the complexities of the whole process, the funding institutions establish thresholds and criteria that a project must comply with to go forward in the cycle and eventually receive funds for its construction. Appendix C includes the present UMTA policy for approval of transit projects.

However, criteria are a way to establish one perception of the problem. As soon as two parties do not agree on the criteria, conflicts will arise as well as the possibility of behaving contrary to the desired outcome, unless the right incentives are established. A narrowly-defined criteria -- based on a limited number of evaluative variables -- can serve the purpose of reducing the complexity of the process and creating a way to evaluate projects that in principle have no single basis for comparison (e.g., a light-rail project in one town with a busway in another town). On the other hand, narrow criteria may be counterproductive in terms of distorting the decision process depending on the decision environment and

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223 The UMTA approach basically uses two cost-effectiveness indices to evaluate the relative merit of a proposal against other proposals. These indices are determined in the alternatives analysis process. One of the two indices account for the level of local effort in contributing to capital funding. The indices depend upon the differences in costs, travel impacts, and financing between the proposed investments and the TSM alternative (that must always be included in any alternatives analysis). A penalty is introduced if a more cost-effective alternative is discovered. This penalty comes in the form of a composite index between the selected alternative and the more cost-effective alternative "discovered". What initial alternatives are considered and shown in the EIS, therefore, may influence how UMTA rates the alternative selected by the local decision makers.
the uncertainty associated with the variables that enter the process \textsuperscript{224}.

The tendency to come out with aggregate measures (e.g., aggregate performance indicators as those suggested by UMTA) can be valuable as a way to narrow down the number of possible alternatives, but not as a single decision rule to decide on the merits of the selected alternative. Aggregate values disregard welfare and political concerns that ultimately are the ones that likely have an overriding role in the decision making process. In fact, if aggregate values do not conform to local preferences, they may be manipulated to reflect such preferences, thus reducing the validity of the technical process \textsuperscript{225}.

As was mentioned before, when uncertainty (lack of consensus about purposes and the means of achieving them) is high, the ability of applying standard (universalistic) criteria is difficult \textsuperscript{226}. By contrast, the absence of specific criteria would likely favor processes of political and social influence bringing the planning process completely outside the realm of the technical sphere.

The different perspectives on the problem to be addressed with the construction of the transit facility (time and scale frames) generates a different preferred criteria at the different decision-making levels. The

\textsuperscript{224} Criteria selection was discussed earlier within the context of the uncertainty associated with the components of the planning process.

\textsuperscript{225} UMTA's rating system tries to reflect the benefits of each project and avoid any bias toward a particular type of project or geographical area of the country. That system - with a strong emphasis on cost-effectiveness criteria - however, has raised a lot of controversy because it does not allow enough possibilities for obtaining funds for a project in a particular area when they are requested for reasons different from the estimated cost-effectiveness.
funding institutions may be interested on cost-effectiveness criteria, while the local decision makers may be concerned about expanding service to be able to achieve particular transportation goals in other parts of the region or to attract the votes of other sectors of the population. The mismatch among the preferred criteria at the different decision-making levels opens up the possibilities for distrust, biasing, and the distortion of the technical analysis.

A middle ground between narrow criteria and no criteria at all was more closely followed in the cases outside the U.S.. In the cases of Madrid and La Paz, no specific criteria existed before the planning process was undertaken. However, initial discussions took place (e.g., the program contracts in the case of Madrid) to lay down the conditions to be achieved with the transit project. This approach is a way to reach a compromise between the advantages and disadvantages of the two extreme approaches for evaluating projects -- i.e., narrow criteria and no criteria at all. Nevertheless, cost considerations also played an important role as incentives were established to encourage the attainment of particular cost-effectiveness objectives in the construction and operation of the selected alternative.

6.4. Presentation of Analytical Framework

The conceptual approach of this research is based on an analysis of the characteristics of the technical process that allow the decision-making process to interact with it. This conceptual approach consists of the elements described in the previous section (6.3).

Figure 6.2 shows a schematic representation of the analytical
framework. The figure highlights the components that affect the interaction between the technical and decision-making processes. These components should be inscribed within the broader framework shown in figure 6.1.

The technical process initially generates, to respond to a perceived need, estimates that reflect some preliminary ideas about the scope and

Figure 6.2
Schematic representation of analytical framework
timing of the project (1). Simultaneously, the decision-making process reacting to signals or pressures from the environment, generates its own ideas about the scope and timing of the project (2). The conflict induces some reevaluation of the technical analysis (3).

The technical process is also influenced by the technical issues (4) mentioned in chapter 4, some of them generated by the conflicts explained in the previous paragraph (5), other by the information gathering and processing activities (6), which in turn are influenced by the uncertainty associated with any of the elements indicated in figure 4.1 (7).

Simultaneously with these flows, some criteria are generated for the purpose of selecting the "optimal" alternative (8). These criteria are evaluated in the decision making process (9) and send back to the technical process if perceived not satisfactory (in terms of their values or the concerns they addressed) (10 and 11).

From another side, and concurrent with the events described in the last two paragraphs, some expectations are built as to the "optimal" project (based or not on the initial estimates generated by the technical process, and affected by other factors, such as the probabilities of getting additional funding). These expectations create some decision payoffs from the decision-making process where some actors may not want to miss the opportunity of getting the project ahead (12). These decision payoffs are also affected by the decision criteria (17) and the incentives or desincentives that may accompanied those criteria. These payoffs evolve in an (accidental or intentional) optimism that permeates into the technical process through (a) how the uncertainty associated with the elements of the technical analysis is treated (13) and (b) how information
is collected and gathered (14).

Finally, the technical process operates on uncertainty (15) by decreasing its level if need is perceived and funds are available. Uncertainty is also appreciated in the decision-making process (16) where further reevaluation of the technical analysis may be requested. (If a complete reevaluation is deemed adequate in the decision-making process, the level of uncertainty may increase rather than decrease from previous technical exercises.)

6.5. Prescription and operational extension

The framework advanced in figure 6.2 helps better understand the dynamics of the planning process and the possible under-estimation of costs, and illustrates the different perspectives that can be taken to analyze a decision-making process (see also section 7.3). It also shows the interaction among the different components of the technical and decision-making processes and allows the development of prescriptive ideas and operational measures with a potential for improving both processes. The operational measures are designed to confront the issues and difficulties highlighted in the analytical framework taking into consideration the different decision perspectives.

Decision makers respond to uncertainty by promoting those elements of the technical process that better support their preconceived ideas about the project. In the face of uncertainty and their attempt to address the requests and needs of the myriad of interest groups, decision makers tend to force (deliberately or unpurposefully) the technical process to emphasize the issues and establish the values that better confirm their
(personal) goals. Sensitivity analyses, carried out to a full extent, should help avoid the difficulties generated by the inherent uncertainty of the planning process 227.

Sensitivity analyses must encompass not only the simple change in some of the values of the input variables, but also changes in the basic assumptions (in terms, for instance, of ridership, financial conditions, or potential funding sources), and changes in the design of the facility. The stronger development of sensitivity analyses would also help address the conflicts that arose from the different scale and time frames of the participants in the process.

Sensitivity analyses can be further expanded through the construction of alternative scenarios. The technical process can be strengthened if consideration is given to the possibility that some of the assumptions taken do not turn out to be as it was initially thought -- such as the fact that utility companies may or may not pay for relocation costs or the communities affected by the transit facility may or may not want fancy landscaping. This approach, however, will only be acceptable if modelling methods are simple, flexible, and clear enough so that the technical process does not grow to unmanageable dimensions and so that the participants in the process can easily perceive the tradeoffs between the different variables and alternatives. The development of scenarios would foster public debate over data and would provide a solid process to decide

227 In the U.S., this approach has been advocated by UMTA as indicated in its new Alternatives Analysis Guidelines. Nevertheless, the extent of these sensitivity analyses is very limited, and still faces the resistance of the local planning institutions due, among other things, to the perceived large computational requirements of sensitivity analyses. There exists therefore ample room for improvements.
how to handle ambiguity and uncertainty.

The decision model developed in section 6.3.3 supports the idea that additional information would lead to less biased results, based on the assumption that additional information would always increase the accuracy of the results (what is certainly likely in the process of estimating capital and operating costs). Sensitivity analyses and additional information can be coupled together in the design of computer-based information systems supporting the negotiating-argumentative role of the technical process. These information systems must contain quick and robust maintenance/update procedures and structured strategies for undertaking sensitivity analyses. In addition, computer-based information systems must be carefully implemented to avoid the common pitfall that they end up serving to blur rather than to clarify the planning process. The systems must be transparent and the assumptions clearly stated so that the participants can perceived the tradeoffs between the different inputs and the results of sensitivity analysis.

The fact that several audiences look at the project (and the technical process associated with it) in different ways and with different interests, creates mismatches that eventually distort the very meaning of the technical analysis (and the confidence the interested parties have on it). On one account, too specific decision criteria cannot address the concerns of the several audiences (e.g., the federal government focussing on cost-effectiveness measures, and the state government focussing on environmental and land use issues) and promotes lack of trust, lengthening of the

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228 The case of La Paz is an example of the possibility of intentionally using computer-based models for political gains. See also Klosterman [1987].
process, and biases in the technical analysis. A broader set of criteria for selecting worthwhile transit investments coupled with a more open negotiation and discussion of which criteria must be ultimately applied can help achieve a more substantial compromise between the different audiences and avoid distortions in the technical process.

Such an approach, accompanied by an adequate and necessary visibility of its development, will shift the focus of social-influence processes -- institutional and political -- to the decision among competing criteria, rather than directly among competing candidates or proposals. This means that attention will be directed not only towards which transit project is the preferred one but also towards the particular set of criteria to be used in evaluating the several alternatives under consideration. In this way, the use of criteria -- e.g., a cost-effectiveness criterion -- that does not meet the needs of particular interest groups -- local decision makers -- would be reduced. In addition, the local context, largely ignored in averaging methods and so crucial in planning processes at the local level, would receive more consideration.

The implementation of such an approach assigns a critical value to the acknowledgement, from the outset of the technical process, of which consequences stemming from any alternative or action should be included in the list of benefits and costs to be used for judging technical, economic, or social feasibility. Essentially, this involves a judgment about whose point of view should be taken and, in turn, about which costs and benefits should be considered as internal to the project and which would be regarded as external. Importantly, as the group of individuals with a stake in the process changes, a shift in "point of view" may occur (and the final
decision may change accordingly).

On another account, and as indicated in the decision model developed in section 6.3.3., there is much room left for establishing the right incentives so that the planning process becomes less distorted (rather than just instating a fixed set of guidelines that must be compulsorily followed, as now is being attempted by UMTA). For instance, the decision model evidences that when no constraints are put on the probabilities of getting funds for the construction of the transit facility, the likelihood of biasing the results decreases. Conversely, if such certainty is not implemented (for obvious reasons, such as appearing too complacent in providing funds), another possibility is to create incentives that would discourage biasing the results in the form of premiums when the final figures (e.g., capital or operating costs) turn out to be close to the estimated ones.

Still another alternative in this direction is an approach currently being promoted in several agencies of the US federal government (although mostly for construction, not for planning)\(^{229}\). This approach, labelled "value engineering," consists of creating a parallel process of technical review by an independent party (not directly involved in the project). Through brainstorming and feedback, new ideas and comments on how each

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\(^{229}\) General Accounting Office [1983a], [1983b], and [1984]. Recently, in a case of an LRT system in Houston, Texas, a peer review process was set to investigate the technical recommendations of the selected LRT alternative (selection accomplished through the UMTA-established alternatives analysis process). The review panel, composed of John Kain, Don Pickrell, Peter Gordon, and Michael Meyer have looked at both the technical and political aspects of ridership and cost estimates as the decision makers were concerned about potential cost overruns or demand underestimation. Michael Meyer termed this process "value planning." (Communication with Michael Meyer, August 15, 1989.)
alternative is trying to achieve the specified goals may help realize about potential flaws and particular ways to perform better in the construction (or planning) process. In addition, the institutions involved in the construction (or planning) of a facility would have the incentive to perform better due to peer review pressures. However, at the planning stage, this approach may promote feelings of interference in the local decision-making process. This is what happened, for instance, in the Santa Clara case when officials from the California Department of Transportation indicated their belief that the process was being biased and the local institutions complained about interference in local matters.

Another component of the technical process where some potential for improvements also exist is that of cost classifications. The main purpose of these classifications is twofold: first, they can help better perceive the tradeoffs between alternatives as changes on some items (e.g., demand) effects variable costs; and second, they can serve to design a funding process that better internalizes costs to the local decision making process by tying outside funding sources to particular project items. For instance, the most uncertain items could be borne by local institutions while the most definite ones (or those that do not vary much with demand, for instance) would be borne by higher level institutions. The linking of funding sources from higher levels of government to more reliable items would internalize at the correct (local) level those items that can be more influenced and affected by the local decision process.

One may argue that such an approach may induce undue conservatism, as local decision makers would avoid getting involved in costly transit projects regardless of their potential economic benefits (for the locality
or for the society as a whole). Although it is hard to generalize, this does not have to be the case as the most uncertain items -- i.e., those that would be borne at the local level -- may not necessarily be a large proportion of the total cost. Rolling stock, station and right-of-way landscaping, street reconstruction, utility relocation, and engineering studies, do not account for more than one third of the total capital costs. Nevertheless, the approach may also force considering less ambitious design standards that stay closer to local possibilities. Operating costs -- that according to this approach would need to be borne largely, if not entirely, at the local level -- would make a harder case for this approach as local funds are usually tight and frequently require the transfer of funds from higher levels of government.

Other possibilities can also help internalize costs to the decision-making process. As was mentioned in section 5.4.4, the project-planning process often goes from design to cost; in other words, first a decision is made about what is wanted -- e.g., an LRT system -- and then the calculation of capital and operating costs is carried out (probably trying to find the lowest cost for the alternative selected). An alternative approach is "design-to-cost"; in other words, first a decision is made about the level of resources available for a particular types of projects -- e.g., transit projects -- from all the possible sources and then a selection is made about that project that best fits those resources.

Although the "design-to-cost" approach would not prevent underestimation, it would help decision makers to be aware of the level of resources available and the limitations imposed by that level; it would also promote

230 Transportation Research Board [1978], pp. 49-51.
discussion and negotiations among the interested parties by forcing an iterative process of "defining-estimating-redefining-reestimating" that emphasizes, from the outset, the level of resources available.  

Overall, this combination of ideas suggests an approach that attempts to tackle the level of uncertainty of some elements (mainly the elements that compose the technical data and methods) and, at the same time, opens the discussion over the assumptions and definitions of other elements of the transit planning process (mainly the goals to be achieved with the transit project and the criteria to be used to judge the merits of each alternative).  

6.6. The Value of the Theoretical Framework in Improving the Estimating Function

The discussion of the technical and decision-making processes in chapters 4 and 5, respectively, and of the analytical framework in chapter 6, have led to suggested improvements in the estimating function that may

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231 In this approach, the higher-level institution would start by defining the transportation needs for the area (in response to a perceived need), and continue by allocating funds (based on their own set of estimates) to the local institution (or institutions), disbursing them, and letting the local decision-making process to make use of those funds for the construction of the locally-preferred alternative. In other words, the higher-level institution would very much stay out of the local decision-making process as it relates to the selection of the transit alternative. Faced with a given amount of external funds, local decision-makers would have to internalize the true costs of their preferred alternative and tend not to underestimate the costs.

232 This approach goes contrary to present U.S. federal policies that attempt to reduce the amount of discretionary funds for transit project (Section 3 funds) while increasing formula funds (Section 9 funds, or those allocated through formula depending on population, land area, population density, revenue vehicle miles, passenger miles, transit route miles, and transit operating costs). UMTA [1988]; General Accounting Office [1987], pp. 246-248.
not necessarily transcend into more accurate cost estimates but will induce a decision-making process that would tend to reflect the limitations and difficulties of the transit-project planning process. The standard planning process has been overcome by the disappearance of the "stable state"\textsuperscript{233}. The planning environment has become one of ever changing needs, regulations, and base conditions. Within this environment, the classic "goal-definition-analysis-evaluation-selection" model of planning sanctioned by the traditional rational paradigm does not match the negotiated, politically-influenced process of decision-making found in the case studies.

The framework incorporates the concerns raised in chapter 2 about the rational paradigm, the critiques to this paradigm, and the role of alternative paradigms. It includes elements that can enhance the effectiveness of the technical process of estimating costs as well as complementary measures to foster a dialogue that would strengthen the "non-rational" elements of the decision-making process. Sensitivity analyses, improved information systems, negotiated criteria, and "accuracy" incentives are the elements that the framework identified to make the process closer to the normative basis assumed in section 2.5.

In addition, the framework proves invaluable in looking at the transportation planning process through the identification and categorization of the elements that create the issues and difficulties found in the case studies. By categorizing uncertainty, we can better discern the constraints and opportunities that exist for reducing the level of uncertainty related to particular components of the technical process.

\textsuperscript{233} Schön [1971].
By identifying the elements that lead to announce one or another set of costs, we can better perceive the choices that are made during the transportation project planning process. By recognizing the different perspectives of the actors in the process, we can better single out the changes that ultimately affect the accuracy of the initial (cost) estimates. Finally, by recognizing the conflicts created by the actors' different implicit goals, we can acknowledge the effects of establishing particular evaluation criteria.

The framework proposed in section 6.4 reflects the methodological approach followed in this thesis. This approach looks at the underestimation problem in a broad fashion and brings insights that could not be perceived from a purely econometric methodology. It acknowledges that a seemingly simple problem -- the calculation of capital and operating costs -- can be viewed in several ways (from the technical perspective and the decision-making perspective). The methodological approach, by exploring alternative problem definitions and corresponding theoretical structures, tries to avoid suggesting a sophisticated solution to the wrong problem.

The framework helped identify the actions that would lead to an estimation process that reduces the chances that bias results are introduced. This does not mean that cost estimates would be more accurate but, at least, that decisions would consider the possibilities of being inaccurate.

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234 For instance, the one followed by Merewitz [1972].
7. CONCLUSIONS

7.1. Summary of Findings

The previous three chapters presented a detailed discussion of the technical process, the decision-making process, and the interaction between both, as they relate to the estimation of capital and operating costs of transit projects. The discussion led to the following major general conclusions:

As to the technical process:

- The prevalent approach to estimating capital and operating costs during the planning stage, the build-up approach, tries to combine characteristics of both the top-down and group-up approaches in an attempt to address the difficulties of achieving a complete and precise cost-estimating process and the constraints generated by time and budget limitations and those that come from the socio-political environment surrounding the planning process.

- Full accuracy can never be achieved because of the inherent uncertainty associated with some of the elements of the technical process -- uncertainty that cannot be fully avoided by gathering additional information, controlling (acting) over the variable, or reaching a negotiated compromise with the institution or institutions that control the values of particular variables.

- Classifications of capital and operating costs, according to their uncertainty and interdependence (e.g., their relation to the demand variable) or how directly they are related to the transportation project (e.g., construction or operating versus administrative costs),
are seldom applied as a tool for better planning, control of uncertainty, and/or delineation of funding responsibilities.

- Sensitivity analyses have hardly been incorporated to cost estimating procedures. The large number of items normally present in cost estimating has prevented the application of sensitivity tests. Reducing the number of items and increasing the scope of sensitivity analysis would better serve the needs of a dynamic technical analysis and the uncertainty associated with it.

- Computer-based information tools have not been applied to its full extent because of the perception that the calculation of costs for a particular project is too specific and has almost no replicability in another project. Furthermore, the implementation of computer-based information systems has usually responded to an attempt to improve the efficiency of cost calculations rather than to the possibilities of using those systems to effectively support decisions and/or serve as an analysis tool in the negotiating process.

- The emerging computer technology backed by the necessary institutional support at the various decision-making levels should allow the implementation of adequate computer-based information systems (for cost estimating in transit project planning). To be fully effective and accepted, however, they must be carefully designed bearing in mind the elements of the framework developed in chapter 6 (i.e., uncertainty, scope and time scales, decision criteria). This will require systems that are transparent and simple and upon which assumptions can be built in and sensitivity analyses easily performed.
As to the decision-making process:

- The institutional and political pressures over the planning process largely affect how decision makers perceive information and how much attention they will put on it (a more detailed discussion is developed in section 7.2). The case studies clearly illustrated the strong pressures over the technical process motivated, to a great extent, by the need to justify previously-taken decisions.

- Difficulties in the decision-making process (that can simultaneously be viewed as challenges) mostly stem from the characteristics of the transportation planning process -- its ill-structured nature, the uncertainty of its elements, the many interested parties gravitating over it, the length of the process, and the unavoidable disjointed organizational setup. To address these difficulties, approaches have tended to confine the process through the implementation of standard technical methods and measures. Yet, it is likely that the type of information decisions must focus on does not fit within the confines of those standard methods and measures.

- Information is not equally relevant to the several layers of the decision-making process and access to it may not be available to all of them at the same time. In principle, the authorization for a new transit system should be sought after the final evaluation and selection of a complete alternative. However, the case studies illustrate that local decision makers try to seek authorization as the decision process takes place, either at the outset or during the
development of the technical analysis 235. For the higher levels in the authorization hierarchy, time is typically limited and decisions must be considered in the light of other strategic decisions and overall resource constraints. Moreover, outside political forces are often brought to bear on the decision at the point of authorization, not before. All this compounds to different in-depth knowledge about the alternatives by the authorizers and other interested parties that the developers of the solution (analysts and local decision makers) probably have. The final authorization is then made by people who often do not fully comprehend the proposals presented to them, and "the comparative ignorance of the [authorizer] is coupled with the inherent bias of the sponsor" 236 (i.e., the local decision maker).

And as to the interaction between the technical and decision-making processes:

- The general framework identified four major actors in the planning and, particularly, cost-estimating process: environment (in a broader sense, encompassing interest groups, community groups, etc.), analysts, decision makers, and funding institutions. These actors confront the particular transit project with viewpoints which normally differ in their scope and time frames. These differences create a situation where the decision maker must respond to conflicting

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235 In fact, in the U.S., due to past experiences, new transit plans start by testing the waters of the federal government in order to come out with some initial probabilities for the chances to attract federal funds.

236 Mintzberg, et.al. [1976], pp. 259-261.
audiences. In the attempt to respond to those divergent audiences, the decision maker would try to influence the technical process, stirring the technical results towards an end that is not necessarily the one dictated by a purely rational method.

Moreover, in spite of the rational nature of the estimating function itself, the cost-estimating process does not fully consider the effects of capital and operating costs in the broader context (e.g., financial consequences, contingency elements, local capacity, etc.) due to the influence and coercions from the decision-making process, creating tensions between funding institutions and local decision makers that do not contribute to improve the accuracy of cost estimates.

Changes in the technical analysis, particularly those that eventually generate increases in the estimated capital and operating costs, come mostly from the long time that it takes to implement the selected alternative and from changes in the design of its elements. To a lesser extent, but also important, increases come from costs related to items whose construction or relocation costs initially are assumed to be in the hands of institutions outside the responsibility for funding and implementing the transit project.

The expectations created in the decision making process that arise from initial project proposals (to perceived needs) and their consequent preliminary technical analyses, what is at stake (for decision makers and analysts) in the announcement of the results of the technical analysis, and the narrowness of the cost-effectiveness criteria for funding a project are factors that influence study
decisions and the deliberate or accidental biasing of the results and/or design of the transit facility with unrealistic elements.

The fact that the long time that it takes to develop transportation plans (from its conception to final implementation) does not help achieve more accurate cost estimates, would tend to suggest that a faster process would improve accuracy. However, a reasonably long period of time is needed to allow for an effective political and social dialogue. If the shortening of the process hampers the chances of a fair dialogue, the accuracy of the analysis would likely diminish anyway. By looking at the planning stage as a argumentative-negotiating exercise, a compromise could be reached in designing an analysis process -- incorporating elements such as those described in section 6.5 -- that would not hinder the political process and notwithstanding would reduce the time from initial project conception to implementation.

The objective of the process of analyzing alternatives should be, in principle, to assist choice, as opposed to making a choice. However that process is often perceived as the mechanism to making choices and ends up being distorted in the attempt to justify previously-selected choices or in delaying the process so that the previously-chosen alternative has a greater chance of being adopted (or not adopted). (See section 7.2 for further discussion of this point.)

These conclusions highlight the interrelationships between the different elements of the technical and decision making processes. They pave the way to the discussion of the role of technical analysis in decision making and to a further review of the debate about rationality in
planning initiated in chapter 2. These two topics are covered in the next two sections respectively.

7.2. The Role of Technical Analysis in Decision Making

Current Roles

The case studies clearly indicate that technical analysis has a role in decision making -- an exercise in bureaucratic paperwork and political tactics -- and that that role is not the supposedly intended one -- the assistance to the decision-making process. The role is distorted because of the way the analysis process ends up being (or is) structured. Such a process tends to be reactive, not starting until a preferred alternative has already been decided upon. Other alternatives may not be considered, may be given only limited attention, or may be "straw alternatives" tossed off to meet the requirements of higher level institutions only.

Furthermore, as the instances investigated in this thesis have illustrated, so much time and so many resources are committed to the development of an analysis supporting the alternative selected as preferable from the outset that, as time passes, it becomes harder and harder, financially and politically, to give serious consideration to major revisions or to new options. The relevance of the long and tedious documents to the decisions about the project then diminishes and the technical analysis ends up being simply a paperwork exercise, a hurdle that consumes resources and adds time to the project development process 237.

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237 Such a process would favor those projects in regions where decision makers are more perseverant or have a higher influence or leverage at the federal level. However, it would not comply with the definition of a "correct" planning process indicated at the end of section 2.5.
The escalation in resources and time reinforces both itself and the futility of the technical analysis. This analysis then seldom serves as the basis for responsible, fully-informed decision making.  

The technical analysis, however, still serves another role, and, at this role, it does serve it well. This role is that of structuring the process: indicating what elements to include, what to discuss, what to look at, what to confront, etc. focusing the terms of discourse and shaping the planning debate. This role is an important one but its usefulness is largely curtailed by failing to achieve the other major intended objective of the technical process -- namely, the effective support of the decision-making function.

**Perspectives on Decision Making**

The case studies and the discussion of the analytical framework illustrated the decision-related characteristics of the urban transportation planning process, among them: (1) the ill-structure nature of its elements (as is typical in socio-technical systems), (2) the significant value content of its decisions, and (3) the significant human

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238 De Neufville [1987] identifies three types of explanations for apparent failures to apply data or studies in policy making: (1) the "partisan" view argues that data and studies are, at most, used to support decisions previously made; (2) the "two worlds" argument states that data and studies are often irrelevant because the analyst and the decision maker operate with divergent assumptions, problem formulations, variables, and time schedules, resulting in studies that appear too late and often focus on variables that are not relevant to decision makers; and (3) the "enlightenment" argument contends that data and studies are influential, but they should be viewed only as background and not as primarily having an impact on particular decisions (p. 86). These three types of explanations were present in the cases investigated in this thesis.

aspects (societal or individual) that are part of the process. Together, all these characteristics nurture the strategic character of transportation decisions, offering the opportunity for the introduction of multiple perspectives in the analysis of the decision-making function. Furthermore, for the type of transit projects discussed in this thesis, there exist not one but several decision processes. These decision processes act on the technical process (and eventually the technical process on them) in order to reach a compromise on a common set of assumptions, data, methods, and results (and put particular ideas forward).

From one perspective, decisions can be analyzed by looking at the different audiences the technical process must respond to (e.g., federal and state governments in the U.S.). Each one emphasizes a different element of the technical process and therefore puts different pressures on the estimating component of that process. For the higher levels of government (funding institutions), thresholds are needed to compare alternatives from very different projects (at least in terms of the goals to be achieved and, possibly, urban environment) that are competing for a given amount of funds. At the local level, on the other hand, the same thresholds are not relevant at all since the purpose of the project will differ from that of the higher level institutions. At any level, figures must be credible, particularly at the local level, for the local institutions must cover any funds required above those provided by the higher level institutions.

From another perspective, decisions can be analyzed in light of the uncertainty of the elements that are part of those decisions. How decisions will be made would depend on the level of uncertainty associated
with the decision elements. For instance, for those situations for which there is a good level of agreement on the goals, assumptions, and data of the estimation process, a more 'rational' process, focusing on acquiring information, would be more likely. For those cases for which there is little agreement, then ad-hoc procedures would be more appropriate.

Decisions can further be analyzed by looking at the stakes of the interested parties. Who is included in the process and what kind of information is deemed relevant would ultimately affect the scope of the estimation process and the changes that may need to be incorporated later on in the process. Decision payoffs, or what benefits and costs the decision will report to the particular decision maker, would influence the use of the technical information and how much further to go in terms of gathering information and how to announce the results of the estimation process.

**Issues and Constraints**

It is important to acknowledge that, in light of uncertainty, information is always interpretive, and "interpretations can be more powerful than facts" \(^{240}\). Moreover, the inevitable role of politics in transportation planning acts as a catalyst for political activity in an effort to control interpretations. Furthermore, information is never complete, never fully and equally available to all participants in the transportation planning process, and may be deliberately withheld. The "strategic manipulation of information" \(^{241}\) must always be considered in any attempt to analyze or carry out the technical process in transportation

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\(^{240}\) Stone [1988], page 6.

\(^{241}\) Ibid., page 21.
The interpretive nature of the transportation planning process has led some authors to conclude that technical analyses are ultimately a middle ground to satisfy several decision making processes (or institutional actors) and are used to produce arguments for each institutional participant to push selectively for those components that better support their positions \(^\text{242}\). Others prefer to state that transportation studies are an expression of power relations between the different layers of the decision-making process \(^\text{243}\). Nevertheless, as discussed in the introductory section of chapter 2, transportation studies reflect the technical, bureaucratic, and political doctrines that are dominant at particular moments -- the broader framework presented in section 6.1 --, giving preference to certain types of reasoning and indicators at those moments.

The framework presented in this thesis suggests that the preferences are influenced by five major factors that affect the connection between technical analysis and decision making: (a) uncertainty, (b) time and scale frames, (c) information needs and flows, (d) decision payoffs, and (e) decision criteria. Decision makers use uncertainty to broaden the support for particular preferences in an attempt to advance their personal or political goals. By making use of the uncertainty, they can force the technical analysis to support their preferences. The technical analysis, in addition, due to the myriad of interests gravitating over it, must be designed to address a variety of time and scale frames. Some of these

\(^\text{242}\) Johnston, et. al. [1988]; Deiter [1985]; Dorschner [1985]; Edner and Arrington [1985]; Hamer [1976].

\(^\text{243}\) Whitt and Yago [1985]; Offner, et. al. [1982]; Whitt [1982].
frames will likely be in conflict; the shifts in their emphases, responding to the preponderance of particular ideas at particular moments in the project development process, will ultimately generate outcomes that have small chances of being closed to initial plans. These small chances are further reduced by the length of time it takes to develop the projects and the hurdles likely put by other institutions to those projects. The reduced chances nourish decision makers' disdain towards the technical process, which then becomes a paperwork exercise, not a decision-assistance tool.

In relation to the scope of the project, the attempt to achieve broad goals with the transit project, beyond the pure transportation-related goals, further endangers the assistance role of technical analysis, for this analysis is surpassed by a socio-political agenda set by the broader goals. These broader goals may not have an easy translation into the transportation study (in terms of benefits, for example), and hence there is a good possibility that the technical analysis becomes distorted by the attempts of the broader and more dynamic political agenda to push the project ahead. Furthermore, the criteria established for the approval of the preferred alternative forces the technical analysts (with decision makers' authority over them) to generate rather optimistic outcomes that, again, may have little chances of being replicated when implemented. Finally, how the decision makers perceive the chances of accomplishing their intended goals -- generated by the myriad of competing interests acting over the decision makers -- also affects the chances of biasing the technical process, reducing its effectiveness.

Very often, while the technical analysis focuses on the costs and
benefits of transit alternatives to society as a whole, decision makers barely find the net social benefit criterion, which is basic to the technical analysis, relevant to their often more limited objectives. If the costs of a decision are (or can be) spread over a large number of people while the benefits are concentrated on a narrower constituency whose support the decision maker seeks, that decision maker will have an incentive to conceal the costs and force the technical analysis to reflect his/her preferences, even if actual costs are in excess of benefits. In such situations, an "unbiased" technical analysis may give results which decision makers (or elected officials acting over them) are hardly interested in knowing. (The decision model developed in section 6.3.3 illustrated how the biasing process can take place.)

Towards Strengthening the Role of Technical Analysis

With these issues and constraints as a background, the crucial question becomes whether it is possible to link more directly technical analysis to decision making and, if it is, what can be done to accomplish that purpose. Ideally, the theory should highlight the kinds of information that are useful to decision makers and under what circumstances, and give an answer to the questions of how and when technical analysis can assist decision makers in shaping their perceptions or the content of their decisions. In this thesis, some elements in the direction of that theory have been identified. These elements should lead to a more effective role of the analysis process in decision making. Subsequent to that role, it is expected that some of the reasons for the underestimation of costs will subside and the chances of generating results

\[244\] De Neufville [1987], p. 86.
closer to expectations will improve.

The operational extensions discussed in chapter 6 and summarized at the beginning of this chapter attempt to make decision makers (and those affecting decision makers) aware of the implications of their decisions as they concern the capital and operating costs of transit alternatives. By internalizing the analysis process and its results, decision makers should strive for the best (and least unbiased) results they can achieve and request this effort from the technical analyst, within the time and budget constraints of the particular project. This does not mean that full accuracy -- in particular, for capital and operating costs -- will be achieved but that analyses will be carried out in a more conscious and objective fashion. The actions in that direction can be summarized as follows:

- Require the performance of sensitivity analyses of simultaneous sets of variables to help perceive the relationship between alternatives and the robustness of results. These analyses imply the acknowledgement of the uncertainty associated with each variable and the nature of the data (including key interdependencies).
- Complement sensitivity analysis with development of scenarios. This scenarios would, first, pay attention to potential changes and trends in the broader environment surrounding the transit project and, second, analyze how these changes or trends would affect the values that enter the cost-estimating process. Furthermore, scenario writing would give passage to the confrontation of the different viewpoints about the transit project and would allow the reflection of that confrontation in the technical process (avoiding that this process
reflects the decision maker’s viewpoint only).

- Require the development of cost classifications, at least between one-time and recurrent costs and between demand responsive and non-responsive costs. These classifications would allow focusing on discussion among different levels of government on which items each one would be responsible for, and at the same time would induce and help decision makers to perceive what would happen if expectations for some variables (mainly, demand) do not materialize.

- Make better use of emerging computer-based information systems and technology to speed up process (in the sense not only of generating prompt results along with potential developments in the political process but also of being able to redo a piece of the analysis whenever new and actual data become available), share information with past and present project development exercises, keep track of changes in and sources of cost-related items, etc. By speeding up the process, chances that the technical analysis respond in a good manner to the requirements of the decision making process and the dynamism of the surrounding political agenda will increase.

- Make the cost model or approach, either formal or informal, as explicit and clear as possible. Particular approaches may blur rather than clarify the process, although the selection of an obscure approach may be done deliberately for other purposes (for instance, attempts may be made to make any particular kind of data -- primarily financial data -- hard to find or interpret). Analysts should strive for transparency as a major characteristic of the cost-estimating approach and its structure should provide incentives to do so.
Complement this explicitiness with a process that creates some pressure on the analyst through argumentation. For example, an approach similar to "value engineering" (see footnote 229) whereby an independent review of the project is undertaken, outside the direct sphere of the decision-making process, to evaluate and assess the validity of the technical results (e.g., the cost estimates).

Nevertheless, such an approach to be endorsed by all or most of the actors involved in the process must strive for pondering all the constraints and opportunities related to the particular local conditions (to avoid, for instance, that a narrow review be rejected at the local level).

The approach must reflect the kind of decision at stake and the need of carrying a flexible technical process that can respond to the dynamism of the institutional environment. A sophisticated analysis process would probably be uncalled for if the decision environment is highly tempestuous and aggressive. An initial simplified analysis could help decision makers establish the framework for posterior detailed analyses within a more controlled environment. Furthermore, in light of the satisficing side of decision making and the fact that qualitative analysis is central to assessing proposals by decision makers, in some situations it would be advisable to follow a design-to-cost approach whereby resources available are first identified, then the value of the proposals is established ("value" in a general sense as the overall value the project would bring about), and then iterative tests are performed to see if the expected costs and benefits are acceptable. In this approach, the decision problem,
through successive iterations, is simplified to make it more manageable and avoid a general weakness of a purely cost-benefit approach that requires knowledge and accuracy about issues and variables which are unknown, ill-defined, and uncertain, particularly for innovative transit systems. In other situations, an approach that combines maximizing with satisficing may be adequate, whereby for some variables and criteria, the analysis would be performed up to optimum values, while for others, satisfactory performance would be enough for the decision at hand 245.

Though some standardization may be necessary or beneficial, narrow criteria should be avoided as the basis for funding a transit alternative. (For instance, standard procedures can be designed in such a way that alternative evaluation criteria can be considered in the process.) Some components of the technical process are relevant to certain decision-making levels but are in conflict with other components that are relevant to a different decision-making level. The most conspicuous example is that of evaluation criteria and effectiveness thresholds that must be passed to move the project forward. Emphasis on narrow criteria simplifies the evaluation process but may induce distortions in the overall planning process. By shifting the focus of discussion to that of alternatives and evaluation criteria, interested parties will become aware of the components of the technical analysis and realize about tradeoffs between variables. This focus would allow affected interests to participate actively in project development -- to propose

245 Mintzberg, et.al. [1976].
alternatives, suggest impacts that need to be considered, and otherwise have a say in the outcome of the studies — and would be crucial to the success of a revised, more effective, transportation planning effort 246.

Though some screening mechanism may always be necessary by the higher level institution, this mechanism can be achieved in phases, starting with a broader set of criteria in the initial stages (criteria that should include the merits of each alternative on the basis of the seriousness of the problem and the objectives that are pursued by the ultimate beneficiaries). That set would be narrowed down to a more specific one as the last stages of the process are reached (and as the number of alternatives becomes smaller including those that are worthwhile to the local decision-making process). At the last stages, the criteria should nevertheless encompass performance measures related to the broader set of merits established in the initial stages of the planning process. The higher level institution would need then to choose among both competing projects and competing criteria and select which ones deserve further consideration and, eventually, funding (and to which extent) based on the institution's goals towards urban transportation and the political agenda prevalent at the moment.

246 In this direction, De Neufville [1987] states: "The positivist view of knowledge on planning practice has encouraged planners to try to be value neutral, to focus on measurable issues and general principles, and see the production of information as distinct from the political process. A phenomenological conception of knowledge on the other hand, focuses on unique and particular situations, and on the everyday world; it emphasizes the subjective meaning of the problems to the actors, it assumes knowledge is constructed in a community rather than having an independent existence, and it accepts that information is shaped by preconceptions. (...) Knowledge developed interactively with knowledge users becomes influential in decisions."
This process would gain in flexibility but would need to be combined with the other suggested actions (e.g., sensitivity analyses, performance incentives, and so on).

- As a consequence of the previous point, the specific methodological and evaluative approaches of the analysis process can hardly be standardized\(^{247}\). There may exist, however, some benefits in standardizing some components as a mechanism to improve the quality of the process and/or its manageability, or reduce the costs of carrying it out. Nevertheless, these conveniences must be weighed against the dynamism of the planning process. This process requires innovation for depending on which criteria are deemed more appropriate, the kind of analysis may change. For instance, if the overriding purpose for one transit project is to improve air quality, the information and technical methodologies of the analysis process would likely differ from another situation where the major concern is to reduce congestion. Moreover, innovation can help simplify the technical process in some situations, and reduce the time to complete it.

- Establish incentives so that the planning process becomes less distorted. For instance, reward good performance on the basis of the criteria selected (for instance, reduction in the carbon monoxide (CO) level in the corridor). These rewards would, for instance, increase the funding level depending on how the final project accomplishes the preestablished criterion thresholds (for instance, a 10 percent

\(^{247}\) Procedural guidelines, however, may be necessary to indicate the steps that must be followed to request funds for a project, including the minimum amount of information that must be reported for the higher-level institution to initiate its own evaluative process.
reduction in the CO level would increase funding for transit vehicles by 10 percent). This approach should encourage, first, to establish reasonable criteria and, second, to try to achieve the goals intended with the transit alternative.

- Establish incentives relating the level of influence of the local decision-making process with the funding of particular components of the project. To the largest extent possible, those components that are largely related to local decisions should be borne by the local institutions. The purpose of this mechanism is that of internalizing at the correct (local) level those items that can be more influenced and affected by the local decision process.

Overall these actions would strengthen the technical analysis and its relationship with the decision-making process as decision makers would have to spell out their perceptions about the transportation "problem" early in the process so as to reflect them in the analysis process. Those actions also increase the communication among the actors as they must discuss the contents and purposes of the technical analysis and agree on the decision criteria. In this vein, the technical analysis would be become the central argumentative element of the process rather than mostly a mere bureaucratic hurdle.

Nevertheless those actions have the dangers of creating a stalemate whenever actors are not able to agree upon the elements of the technical analysis or the evaluation criteria. They will also increase the amount of time that higher-level institutions would need to put into the discussion of the criteria and the evaluation of different alternatives. And they will never eliminate political favoritisms. In the end, however, the
suggested actions should render an estimating process that reduces deliberate biases and yields more accurate outcomes.

Conclusions

These strategies take into consideration that decision makers mostly see the technical analysis as a response to higher-level requirements but largely useless. This perspective distorts the technical process although it serves well the purpose of putting ideas and actions forward. The different actors have different time and scale frames and different objectives to be achieved with the transit project. The clash of these differences cannot be solved if the analysis process is confined to narrow limits. For the process to be more effective, it must allow for negotiation not only in the goals to be achieved but also in how to undertake the analysis (e.g., evaluation criteria).

The communication between the technical and decision making processes increases the possibilities of biased estimates. On the other hand, the communication is needed as the only way for the technical analysis to perceive the many issues involved in the transportation planning process and to incorporate them in the technical evaluation. Without that communication, a larger discrepancy between estimates and actual values would probably occur. The communication serves as a way to reduce uncertainty, particularly the one labelled "actionable." It also serves as a learning tool for the interests involved in the planning process. How much learning can take place, however, is not trivial. The sophistication of some of the techniques may be too high to prevent any learning. In addition, learning may happen in the opposite direction,

\[\text{Ines [1988].}\]
since distortion is always possible (e.g., people may think that one alternative is better than another based on distorted, biased information).

Some of the strategies indicated above attempt to reduce the biasing of results and improve the possibilities of learning. In addition, the technical studies can set a basis for litigation, encouraging analysts and decision makers to avoid excessive distortions of the process. Litigation however is a poor function for a transportation study. The alternative is to open the analysis process to scenario writing and design, sensitivity analysis, and discussion of evaluation criteria. This approach can be, if nothing else, "an important tool for communication" 249, and can help generate a "learning" environment. The adequate articulation of such a framework would allow the "synergy" of the technical (positivist) approach and the social-argumentative approach.

The purpose of the technical analysis is not to achieve the truth (that may only be the correct purpose under very particular situations), but rather to inform the interested parties about the consequences of alternative actions and, ultimately, help them reach a consensus about which alternative to pursue. However, since the technical process falls in the hands of some actors (and not of others), and knowledge about the elements of the process is never complete, it also serves the strategic purposes of particular actors. That is why by recognizing the components of the framework presented in this thesis, mechanisms can be established to improve how the technical process is undertaken to avoid distortions and biases. In this vein, particular mechanisms such as those presented in the preceding section can contribute to achieve consensus and serve the

249 Pearman [1988], page 83.
decision-making process effectively, by giving it the right warnings and the right incentives.

7.3. Recapitulation: Some Views with Hindsight

A manifest dissatisfaction with the results of technical analyses in transportation planning and the burden that (deliberate or accidental) technical errors may create on national and local economies led to investigate the reasons for the underestimation of capital and operating costs from a process (behavioral) perspective and to identify the components of a framework that shows the interaction among the elements that shape those technical analyses and the decisions that accompany their results.

As data and methods cannot usually be adapted to the complexity and dynamism of some public policy issues, the underestimation issue is looked upon within the realm of an approach --the social-argumentative paradigm-- broader than the one that would be dictated by a more quantitative one (for instance, a statistical approach). The social-argumentative approach looks at the process as a tool both for argumentation and for structuring the dialogue. It led to highlight the difficulties imbedded in several components (such as the decision criteria, the management of information, the perspectives on the problem, and the ill-definition of some of its elements), and to suggest particular actions to address those difficulties.

This section develops a view with hindsight about the possible ways the proposed framework and the subsequent recommended actions could improve the cost-estimation process in transit project planning and what would have happened had these actions been applied to the situations of the case
studies. In addition, it further highlights some general conclusions about the conditions (or characteristics) that would actually influence the way decision making uses technical analysis.

The effective consideration of the normative basis stated in section 2.5 implies the opportunity to make informed decisions. The strengthening of quantitative techniques is a necessary step in this direction. However, this strengthening must always be accompanied by the recognition of its limitations and the acknowledgement of its potential roles. Difficulties seldom lie with the quantitative elements in the strict sense. The design of an efficient system on paper does not necessarily help overcome the resistance offered by, for instance, institutional restrictions or a host of economic and political interests that inhibit an unbiased and impartial analysis of options. The reason for this mainly stems from the fact that who benefits from and who pays for the construction of a transit facility may require far more attention that the question of which alternative is more efficient or generates the greater net of benefits over costs (e.g., has the best cost-effectiveness index, however this index in defined). That is why the proposed framework underscores the need for changes in method and attitude arising from the inability of the more quantitative and conventional methodologies for handling the socio-political, institutional and personal aspects of problems that stir a substantial involvement of public interests. And that is why the framework also emphasizes the consideration of how the analysis can be constrained by the institutions and individuals affected by the implementation of its results.

This does not mean to translate into the discredit of the development and improvement of technical methods and approaches. Technical analyses
are a fundamental tool in assisting and shaping decisions (as shown in the La Paz case study). Nevertheless, decision-makers and analysts alike must appreciate its limitations and acknowledge what to expect from it. In particular situations, what to expect from technical analyses should be rather modest, and that may dictate the use of particular methodological approaches (in terms of complexity, flexibility, etc.). Technical analyses can help (1) reduce the complexity of problems to manageable proportions; (2) eliminate from consideration the demonstrably inferior alternatives; (3) find one alternative that all interested parties can accept even though they are not fully satisfied; (4) widen the area of informed judgment; and (5) yield insights, particularly with regard to the dominance and sensitivity of the parameters.

In order to achieve those roles, technical analyses must be understood as an argumentative and structuring component -- that emphasizes the process rather than the product -- within the overall planning exercise. Furthermore, in order to reduce the possible distortion of its results and increase its assistance role, the stakes of the actors must be somewhat internalize into the process. When analysis emphasizes the product and the actors' stakes are barely internalized, the technical analysis often becomes an end in itself and tends to be used for unintended purposes (like the support of previously-made decisions). The US cases clearly illustrated how participants can become bogged down in technical quibbles to fit the results within the guidelines of the higher-level institution and meet universalistic criteria in their attempt to make the initially-preferred project worthwhile to the eyes of that higher-level institution.

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250 Quade [1989].
What are the main implications of the proposed framework and the suggested actions for the case studies? In general terms: (i) sensitivity analyses should have shown that some alternatives were not discernable from others; (ii) incentives (along the lines of those used in the program contracts discussed in the Madrid case) should have prevented excessive distortion of demand and cost estimates; (iii) discussion of evaluation criteria at the beginning of the technical process should have produced a less beleaguered process; and (iv) some systems may not have been built (although this would have been unlikely in the situations of the US case studies discussed in this thesis because of the strong political motivations prevalent during their development) or at least should have been built to less-ambitious design standards.

In addition, the whole planning process should have taken less time as the discussion of technical and methodological disagreements from the outset would have cleared the way to a more speedy process at the end, avoiding the threat of stalemate, endless discussions about very specific figures, and decisions drastically made outside the technical arena. Advancing the discussion of the most controversial points (including evaluation criteria) at the beginning should likely reduce the time to complete the studies (and implement the selected alternative). This is because, though additional time would need to be spent at the beginning, at the end, the process would run smoothly and with less tendency to bias the results and produce undue tensions among the interested actors.

The adequacy of methods to the decision environment (i.e., level of sophistication, cost classifications, etc.) and the use of flexible database management systems would further allow one to put in place an
iterative process whereby assumptions can be tested and tradeoffs easily perceived. Analysts should then be able to respond faster to shifts generated in the political arena and increase their chances of shaping that arena instead of being fully overpowered by it. These aspects underscore the value of quantitative analysis and the value of flexibility (as happened in the case studies abroad).

In response to a local initiative, the process should start with discussion of the goals, the range of possible options, and the criteria for the selection of the best alternative. The local participants would tend to portray the alternatives as the best for the purposes of particular goals (and may tend to select those goals and criteria for which those alternatives are best). The higher-level institution, with its own set of concerns (goals), may or may not coincide with the local level in its perception of the problem, the goals, or the evaluation criteria. If it does not, the proposal would be rejected. If it does, the proposal can go forward and new discussions would be started to work on the technical details, identify particular alternatives, and the specific criteria to evaluate them. This would mean that project construction would be granted at this moment, subject to a limit for the funds to be disbursed based on the extent to which the goals are important for the higher-level institution (and possibly the pressures from the political side) and perhaps earmarked to particular items of the project proposal. The agreement would involve incentives for good performance (in terms, for instance, of reaching the expected demand and keeping costs within small variations of the estimated ones). Similarly, bands of performance indicators should indicate the higher level institution the reasonability
of the results of the technical analysis (and peer pressure can be introduced by calling, as it has been done recently in the US, on the expert advice of independent parties).

In Buffalo, a concern about economic development (and comparisons with the city of Toronto) forced the presentation of the alternatives with rather low capital and operating costs and with a radically unconventional design. A more open discussion of decision criteria might have indicated that the construction of the rail transit system might not have been the most adequate means to bring economic development to the region and that a different set of design standards (less ambitious and more flexible) would have been more adequate (with more emphasis on the achievement of economic-development goals). Sensitivity analyses should have shown that the preferred alternative was not necessarily the best performing one (according to several criteria) and the potential variations in its costs and the burden to the local economy if some of the assumptions change. Performance incentives should have decreased the apparent lack of interest in knowing more about utility networks along the transit corridor and the potential costs to relocate them.

In Santa Clara, the concern was congestion as well as rehabilitation of the downtown area (with the aim of changing land use patterns towards higher residential densities). Community participation was extensive but the technical analysis could not follow it (or did not try to). There was a latent dichotomy and competition between freeway and transit advocates and, within this latter group, between bus and rail supporters. Had the analysis been used to take consideration of these arguments, more insights should have been gained into ridership estimates and the implications of
these estimates on the rest of the variables. Moreover, evaluation criteria would have played a more predominant role. The in-depth discussion of assumptions, goals, and criteria from the outset would probably have led to the development of a more transparent technical process and would have reduced the possibilities of (deliberate or accidental) distortions.

In Boston, the local interests emphasized congestion and environmental concerns, within the constraints generated by existing transit technologies. The proposed actions would have diminished the apparent juggling with cost-effectiveness measures and would have reduced the mutual distrust among neighborhood groups and local institutions as well as the strains between the state and federal governments. The technical process would have been improved with the discussion of criteria and a more open questioning of assumptions and tradeoffs (e.g., phasing of alternatives, changes in ridership) with communities and the federal government. The mistrust (largely created because of the emphasis on cost-effectiveness criteria) prevented a complementary relationship between the local decision-making process and that of the higher-level institution.

How can the higher-level institution compare alternatives that come from different places if criteria among them are different? (For instance, Buffalo’s system emphasizing economic development, Santa Clara’s land use changes, and Boston’s traffic congestion.) As indicated in page 307, criteria would follow a pyramidal pattern whereby, initially, for the purposes of coalition building, a set of broader indicators is used and, further along the process, these criteria becomes more specific, though incorporating (through performance measures) the concerns expressed by the
local interests at the outset. The higher level institution would then have to compare competing projects and competing criteria with its own agenda of goals and political constraints, and decide on which set of projects to fund and to what extent.

In this approach, furthermore, decision makers at the different levels would based their decisions on a broader set of indicators and tradeoffs, not necessarily more information. Moreover, the approach takes into account that decisions do not always fit the homogeneous decision-makers' model as often the individuals whom a study is done for are no more than key participants in a decision-making process; it can enhance the possibilities of a productive dialogue that uses the technical analysis to bring others to discuss their points of view and reach a consensus.

In addition, the assistance role of the technical analysis can be better achieved if decision makers perceive the need to get involved in its development and outcomes. That perception can be heightened with the right incentives, the internalization of some of the outcomes, and the correct structuring of the process to better serve (not necessarily reflect) the needs of the decision-making function. But how would the decision makers be induced to pay greater attention to the technical process? If the process focuses more on decision criteria, decision tradeoffs, and decision payoffs (incentives), they would likely tend to intensify their interest about the implications of their decisions as their own role in the development of the technical process becomes more fundamental.

Some of these conclusions may seem obvious. It is however surprising to find how unlikely they are taken into consideration. This is mainly a consequence of a prevalent perspective that limits the purpose of the
technical analysis and the way criteria and methods are selected to choose among alternative projects. The acknowledgement of a perspective that sees the technical process more as part of an argumentative and structuring process can contribute to improve its function and strengthen the overall transportation planning process.

7.4. Limitations of the Research

The process-orientation of the research (process in the sense of explicit and implicit procedures) proved valuable to achieve the objectives of the thesis. By looking at the different steps of both the technical and decision-making processes, the thesis helped realize about the difficulties, constraints, and issues involved in the cost-estimating function. Furthermore, the multiple-perspective approach assumed to analyze the decision-making process helped identify the different components of that process and their connection with the technical process. It also helped perceive the stakes of the actors involved in the process and the various decision-making processes that take place in transit-project planning. The approach also helped explain the relevance of technical analysis and its role as a means to meet organizational requirements or justify previously-made decisions.

By taking such an approach, however, the research did not permit to focus in detail on particular elements of the estimating function and to achieve more specific conclusions about particular elements of that process. Some examples of these specific elements or conclusions are the following: (a) under what specific conditions costs would be accurate; (b) how sensitivity analysis should be carried out; (c) which kind of
organizational setup would better support particular decision-making environments; (d) what would be the specific components of an effective computer-based cost information system; and (e) which kind of specific cost models are suitable for specific institutional environments and characteristics of decision makers. Furthermore, some specific components of the analytical framework, such as the decision model developed in section 6.3.3, could not be actually tested (although their development was strongly supported by evidence gathered from the case studies).

Finally, the process-oriented approach limited the number of case studies the research could focus on. The consideration of a larger number of case studies could have brought additional insights into some particular issues. For instance, the consideration of a broader set of case studies may have helped identify situations where a stronger positivist role of technical analysis in decision making was in effect (at least stronger than in the cases discussed in this thesis). A broader set of case studies may have helped to single out that combination of, say, technical characteristics, decision makers' personalities, and institutional conditions that more likely makes objective technical analysis an overriding factor in the process of selecting the preferred alternative.

7.5. Areas for Further Research

This thesis has presented a framework for the estimating function in the planning process. Further research could be undertaken on each one of the elements of that framework. By focusing on some of these particular elements, further insights could be gain on how the analysis process could be forced to be closer to a normative ideal (as it relates not only to the
rational paradigm but also to the social-argumentative one).

The following are some areas that deserve further research:

(a) Approaches to sensitivity analysis and scenario writing; alternative techniques and their characteristics; and how they should be implemented to make them useful to decision makers. This research would not simply focus on the rational techniques to sensitivity analyses and scenario writing but also on how their use can be tailored to the decision-making process so that their results are considered in an effective manner for the decision makers to perceive the tradeoffs between uncertainty and outcomes.

(b) Particular technical components of the analysis process such as the role of contingency factors in the estimating function, the development of cost classifications, or the design of efficient and transparent database structures. This area could also include approaches and specific proposals to improve government regulations for capital project evaluation. This research would be geared towards strengthening the theoretical basis of the cost estimating function on those components, methods or techniques, that have the possibility of improving the linkage of the technical analysis with the decision-making process.

(c) Kinds of (explicit or implicit) decision criteria being used by decision makers to select transit alternatives. This research would analyze in depth the issues related to decision criteria discussed in section 5.3, and would identify and compare the appropriateness of particular different types of criteria in terms of their equity (across alternatives) and efficiency (allocating specific costs and
benefits to different alternatives) characteristics, and their technical requirements (or how hard it is to calculate a particular type of criteria).

(d) Assumed role of technical analysts and decision makers in the transportation planning process. This research would undertake an empirical investigation (through surveys) on how technical analysts and decision makers perceive their roles in transportation planning and how those assumed roles actually affect the development of the process (e.g., time to undertake a particular study) and its final outcome (e.g., its accuracy or effectiveness).

(e) Organizational issues. This research would delve into the investigation of the types of organizational frameworks that sustain a stronger or weaker role of the technical analysis. In light of the unavoidable discontinuities of the transportation planning process, this research would test alternative hypothesis about the types of organizational settings that tend to minimize the negative effects of those discontinuities (see section 5.4.3).

(f) Incentives to the achievement of a normative ideal, along the lines advanced in this thesis. Further research should be undertaken on incentives that can be incorporated to particular criteria or institutional processes to (a) make interested actors (e.g., decision makers) to effectively internalize the outcomes of their actions (e.g., decisions) and (b) reduce distortions in the planning process.

(g) The cases illustrated that transit proposals often come about because of the perception that only fixed-guideway systems can help revitalize central areas or redirect urban growth (influencing land use
patterns). The exact relationship of the construction of transit facilities to these impacts is far from conclusive. At most, theories seem to support that transit facilities are necessary but not sufficient to generate those impacts. There is a need to nail down the investigation of what factors, particularly institutional, would help achieve the goals that so often are assigned to transportation projects of the kind investigated in this thesis. (Initially, transit projects may help boost particular urban areas; but later, if increases in operating deficits are not offset by gains in productivity, those projects can become a burden to the local economy, unless subsidies are secured from higher level institutions.)

(h) Comparative operating costs. As illustrated in some of the case studies, local decision makers often claim that rail operating costs are lower than bus operating costs. This assertion is a key one in the attempt to raise constituency support for rail-based alternatives. Transit systems in place, however, do not definitely back this claim (in part because ridership falls below expectations). Further research should be done in this topic with the aim at better relating operating costs to the characteristics of particular transit systems and to ridership figures.

(i) Finally, the role of computer-based information and, in more general terms, the impacts of the way information is presented to decision makers. It is often hypothesized that computer-experienced decision makers would be more suspicious or less confident of computer-derived information than would the non-experienced. (Computer-experienced people know its limitations and, therefore, are probably less
influenced by information that is computer generated than they would be by information presented in a more traditional format. On the other hand, non-experienced people may hold the computer in reverence and thus place too much confidence in computer-generated information, and may be more influenced in their choice activity by information that was computer generated than by identical information presented in a more traditional medium.) The research would look at the implications (advantages and disadvantages) that alternative methods of presenting information have on decision makers' choices (e.g., the possible biases that computerized information may introduce into the selection process).


Downs, G. and Larkey, P. (1979) "Theorizing about Public Expenditure Decision-Making: (as) if Wishes were Horses . . .," *Policy Sciences*, 11, pp. 143-156.


Womack, J.F. and Altshuler, A.A. (1979) *An Examination of the Transit Funding Process at the Local Level*, prepared for US Department of Transportation, Urban Mass Transportation Administration, by the Center for Transportation Studies, MIT.


APPENDIX A

LIST OF INDIVIDUALS INTERVIEWED

Boston

Steve Polechronis (Massachusetts Bay Transportation Authority)
Ernest Deeb (Massachusetts Bay Transportation Authority)
James Scalon (Massachusetts Bay Transportation Authority)
Bob Lepore (Consultant, Cambridge Systematics)
Frank Hynes (State Representative from Marshfield)
Robert Ambler (State Representative from Weymouth)
Pamela Wolfe (Consultant, Sverdrup Corporation)
Rudy Martinez (Consultant, Sverdrup Corporation)
John Noran (Consultant, Sverdrup Corporation)
Richard Doyle (Regional Administrator, Region I, UMTA)
Don Emerson (Urban Mass Transportation Administration)

Santa Clara County

Dave Minister (Santa Clara County Transit Agency)
Gerald Drake (Consultant, Wilbur Smith Ass., Western Region)
Hal Wanaselja (Consultant, Hill International, San Francisco)
James Beall (Councilmember, City of San Jose)
Brigid Hynes-Cherin (Regional Administrator, Region IX, UMTA)
James Graebner (Former Director of Santa Clara Transit Agency)
Don Emerson (Urban Mass Transportation Administration)

Buffalo

Gordon Thompson (Niagara Frontier Transportation Authority)
Paul O’Brien (Niagara Frontier Transportation Authority)
David Franko (Niagara Frontier Transportation Authority)
Operator at Control Room (Niagara Frontier Transp. Auth.)
Don Emerson (Urban Mass Transportation Administration)

Madrid

Francisco Fdez. Lafuente (Technical Director, Consorcio Regional de Transportes, Madrid)
Javier Bustinduy (RENFE, Director Cercanias, Madrid)
(The author worked at the subway company and as participant observed the development of part of the elements discussed about the Madrid case study)

La Paz

Eduardo Beteta (Consultant to La Paz project)
Robert Panfil (The World Bank)
(The author was a direct participant in the transportation project discussed as part of the La Paz case study)
LIST OF NEWSPAPERS REVIEWED

Boston

The Boston Globe
The Patriot Ledger
The Hingham Mariner
The Enterprise (Brockton)
The South Look

Santa Clara County

San Jose Mercury
The Mercury News
Sunday Mercury News
San Jose Metro
Guadalupe Corridor Report

Buffalo

The New York Times
The Wall Street Journal
The Buffalo News
The Buffalo Evening News
The Buffalo Courier-Express
The Tonawanda News
The Buffalo Business Journal
Business First of Buffalo
APPENDIX B

TECHNICAL REFERENCES


Consejeria de Politica Territorial, Direccion General de Transportes (1988) "Estrategia de Transportes en la Region Metropolitana de Madrid," Madrid, Spain (June).


Joint Policy Committee of the Association of Bay Area Governments and Metropolitan Transportation Commission (1979) "Santa Clara Valley Corridor Evaluation: Summary," San Jose, California (March).


Kellogg (1985) "Comparative Analysis of the San Diego Trolley and the Portland Banfield Light Rail Projects to Determine the National Policy Impacts and Implications for UMTA Financial and Technical Assistance," prepared for the Urban Mass Transit Administration (February 19).


Massachusetts Bay Transportation Authority (1987) "Old Colony Railroad Rehabilitation Project: Report Number 9, Methods and Results: Operating and Maintenance Costs," prepared by Sverdrup Corporation (December).


Niagara Frontier Transportation Authority, Metro Construction Division (1976) "Evaluation of Transit Alternatives: Buffalo - Amherst - Tonawandas Corridor, Staff Conclusions and Recommendations," (February).

Niagara Frontier Transportation Authority (1985) "Metro Rail and You", advertising brochure (May).

Niagara Frontier Transportation Authority (1987) Internal Memorandum (excerpts) (May 8).


Santa Clara County Transportation Agency (1983) "Guadalupe Corridor, Busway/HOVway: Response to UMTA Comments on the Supplemental Analysis," San Jose, California (September).

Santa Clara County Transportation Agency (1983) "Guadalupe Corridor: Briefing Booklet," San Jose, California (June).


United States Department of Transportation, Urban Mass Transportation Administration (1981) "Guadalupe Corridor, Alternatives Analysis: Draft Environmental Impact Statement," in cooperation with California Department of Transportation, Association of Bay Area Governments, Metropolitan Transportation Commission, City of San Jose, City of Santa Clara, and Santa Clara County County Transit District (July).

United States Department of Transportation, Urban Mass Transportation Administration (1977) "Buffalo Light Rail Rapid Transit Project: Final Environmental Impact Statement" (December).


United States General Accounting Office (1987) "Grant Formulas: A Catalog of Federal Aid to State and Localities" (March).

United States General Accounting Office (1986) "Procurement: Selected Civilian Agencies' Cost Estimating Process for Large Projects," Briefing Report to the Chairman, Committee on Governmental Affairs, United States Senate, GAO/GCD-86-137BR (September).


United States General Accounting Office (1984) "Greater Use of Value Engineering has the Potential to Save the Department of Transportation Millions in Construction Costs," Report to the Secretary of Transportation, GAO/RCED-85-14 (November).

United States General Accounting Office (1983) "UMTA could take steps to reduce costs in the development of light rail projects," GAO/B-211567 (April).


APPENDIX C

UMTA Approach to Ranking Investment Projects

A Detailed Description of UMTA's System for Rating Proposed Major Transit Investments

May 1984
A Detailed Description of UMTA's System for Rating Proposed Major Transit Investments

1. Introduction

This paper provides a detailed description of the system used by the Urban Mass Transportation Administration (UMTA) to make funding decisions on major transit projects proposed for Federal assistance. The rating system has been designed to provide a rational approach to the allocation of Federal funds in a setting where the demand for Federal assistance far exceeds available resources. Recent estimates of the costs to complete all of the fixed-guideway projects being considered in the country approach $20 billion. In contrast, Federal discretionary funds currently available for new start projects are approximately $400 million per year.

The paper focuses on UMTA's development of project ratings and allocations of discretionary funds. The ratings and funding decisions are based on data produced cooperatively by State/local agencies and UMTA during planning and engineering studies. Since the rating system requires no additional information beyond that routinely available from these studies, this paper gives little emphasis to basic technical methods. A discussion of these methods is presented in "Technical Guidelines for Alternatives Analysis," available from UMTA's Office of Grants Management.

This explanation of the rating system is provided with the expectation that it will permit a better understanding of UMTA's decisionmaking and sharpen the focus of planning for major transit projects on the cost-effective use of Federal, State, and local resources.

1(a) Background

On May 18, 1984, UMTA published in the Federal Register a revised policy on major transit investments. The policy reaffirmed UMTA's process for planning and development of major transit investments, established in previous policy statements. More significantly, the revised policy clearly stated the criteria and methods UMTA uses to evaluate the merits of proposed major transit projects for Federal assistance. These criteria were used by UMTA to recommend projects for Section 3 new start funds in Fiscal Year 1985.

In the future, some modification may be made in the details, though not in the overall structure, of the rating system. In designing the system, UMTA has necessarily restricted its data requirements to the information currently available from completed studies -- alternatives analyses and preliminary engineering efforts. A likely area for improvement over currently available data is in the measurement of transportation benefits accruing from the projects. With specific guidelines from UMTA, local and State agencies will be able to produce more detailed estimates of these benefits than the somewhat aggregate measures that are currently available. As these data are developed, some aspects of the rating system may be revised to incorporate the information.
1(b) Applicability

This system applies to proposals for funding under the "New Starts and Extensions" category of Section 3 and to similar fixed-guideway projects proposed for funding under the discretionary portion of the Interstate Transfer program. Ratings will not be developed for fixed-guideway projects proposed for funding exclusively with funds under Section 9 or under the formula-allocated portion of the Interstate Transfer program. However, projects in both of these categories will be subjected to threshold tests for minimum levels of cost-effectiveness.

1(c) Overview and Definitions

The UMTA rating system is best described as a method for the allocation of Federal assistance. It is used to ensure that whatever discretionary Federal funds are available for major investments are directed toward the best projects. To accomplish this, the system compares projects against each other and identifies those that have the highest relative merits. This approach is quite different from one that would evaluate each project in isolation and attempt to identify each project's absolute merits -- whether its benefits exceed its costs.

A clear definition of terms is crucial to an understanding of the rating system and its use in funding decisions. Five terms represent the key feature of the development and application of the system.

- Federal objectives in urban transportation
- Criteria to measure performance on each objective
- Indices that measure combined performance on all objectives
- Ratings that indicate UMTA's overall assessment of the project
- Funding decisions that optimize the allocation of available funds

The entire rating system is based on a specific statement of UMTA's objectives in assistance to State and local governments providing public transportation services. These objectives are clearly stated in past legislation, have evolved over the years in dialogue between UMTA and the
Congress, and are reiterated in the May 18 policy statement. Section 2(a) of this paper summarizes the objectives.

To indicate the extent to which a proposal meets these objectives, UMTA has identified, for each objective, one or more criteria to measure project performance. These criteria are designed to reflect all of the benefits generated by each project and to avoid any bias toward a particular type of project or geographical area of the country. Section 2(b) identifies the criteria and explains how performance on each criterion is measured.

To combine the various criteria into a small number of indicators of investment worthiness, UMTA computes two indices that compare the trade-offs between costs and benefits from two perspectives. One index represents the Federal perspective, comparing benefits against the required Federal investment. The other represents society's perspective, comparing benefits against total costs. In computing the indices, UMTA applies several threshold tests to screen out any projects that are clearly unattractive proposals for Federal assistance. Section 3 of this paper explains the computation of the indices and identifies minimum performance levels required for projects to be considered for Federal funding assistance.

The indices are applied with judgment, recognizing that uncertainties exist in the data used in their computation. Rather than a mechanical conversion of the indices into a ranked list of projects, UMTA assigns a rating to each project to represent its overall merit. The number of proposals assigned any particular rating is determined solely by the merits of the proposals. Projects receiving the same rating are ordered judgmentally, with reference to their performance on all criteria and emphasis on the magnitude, stability, and reliability of local financial commitments. Section 4 discusses UMTA's assignment of a rating to each project.

Given the project ratings and the estimated balance of UMTA's authorization not covered by letters of intent, UMTA recommends funding of the most highly rated projects that have completed preliminary engineering and a Final Environmental Impact Statement. In making this recommendation, UMTA considers other highly rated projects currently in preliminary engineering, since these projects are likely to be ready for funding decisions within the current authorization cycle. Section 5 of this paper discusses the development of funding recommendations.
2. Objectives and Criteria

A meaningful evaluation of major investment proposals from the Federal perspective depends upon a clear statement of the Federal interest in urban mass transportation. Drawing upon both recent and past legislation for guidance, this section sets forth UMTA's goals and objectives and identifies the measures that UMTA uses to quantify project performance on each criterion.

2(a) Federal Objectives in Urban Mass Transportation

The rating system is based on the overall objectives of the UMTA program, derived from the findings and purposes contained in the Urban Mass Transportation Act. Two primary purposes of the program, according to the Act, are to "assist in the development of improved mass transportation facilities, equipment, techniques, and methods" and to "encourage the planning and establishment of areawide urban mass transportation systems needed for economical and desirable urban development." In the most general sense, then, the overall Federal interest in transit is the provision of an essential level of urban mobility for the public by financially assisting the development of efficient urban mass transportation networks.

The primary emphasis here is on transportation service and the mobility it provides. Several other considerations, ranging from economic development to pollutant reductions to energy conservation, are secondary, but are so closely related to improvements in mobility that they are implicitly included in both the Federal objectives and the evaluation system. Beyond these, however, are additional considerations, such as image and amenity, that are outside the primary Federal interest. The rating system does not preclude local governments from proposing projects which tend to maximize such benefits, but it identifies the extra costs and accounts for them in the rating process.

2(b) Criteria for Assessing Project Performance from the Federal Perspective

There are no perfect criteria for measuring how well proposed transit projects meet the Federal objectives. However, the Congress and UMTA have identified several criteria that reflect the extent to which a major investment proposal attains these objectives within the limited resources of the UMTA capital program. These criteria are stated succinctly in the 1984 Appropriations Conference Report. They include:

- cost-effectiveness;
- local fiscal effort, including the stability and reliability of local funding sources;
- private sector participation;
- the results of alternatives analysis;
- participation of disadvantaged business enterprises; and
- support by local governments and the community.

All of these criteria are incorporated into UMTA's rating system. The first four criteria are used to compute indices that provide an objective basis on which to compare investment proposals. The fifth criterion, participation by disadvantaged businesses, is applied through a minimum standard that proposals must meet to be eligible for Federal funding. The last criterion, local
support, is highly related to local fiscal effort and private sector participation. It is also considered, together with all of the other criteria, in the development of UMTA's final judgment on the overall merits of each project.

For each criterion listed above, one or more measures have been developed to quantify the performance of projects in terms of that criterion. The selected measures are comprehensive, in that they capture fully the benefits of interest to the federal perspective, and objective in that they avoid any bias toward a particular kind of project or particular geographical region. Thus, the measures provide a sound basis with which to identify projects that provide the highest return on the investment of limited Federal resources.

Cost-Effectiveness Within UMTA's rating system, cost-effectiveness means the extent to which a project returns benefits relative to its costs. The cost-effectiveness of a proposed major investment is measured in terms of its added benefits and added costs when compared to lower cost options. The lower cost option of primary interest is the Transportation System Management (TSM) alternative included in every alternatives analysis. The TSM alternative includes such low cost actions as traffic engineering, transit operational changes, and modest capital improvements. It is designed to address specific transportation problems in the corridor and demonstrate the extent to which these problems can be solved without a major investment in new facilities. The TSM alternative is designed within real world limits -- street capacity to accommodate bus movements, financial resources to fund operating deficits, and so forth -- and is therefore a realistic option that represents a true alternative to major new transit facilities. The TSM alternative provides a baseline beyond which it is possible to isolate the added costs and added benefits resulting from a proposed major investment.

The TSM alternative also plays a key role in ensuring an even-handed comparison between cities whose transit properties may today have very different levels of service efficiency. For a property that has already taken most low-cost steps to improve their operations and service, the TSM alternative is likely to include significantly fewer actions than would the TSM alternative for a property where less has been done to improve efficiency. In both cases, then, the TSM alternative represents the best that can be done without a major investment, rather than what has been done so far. Since cost-effectiveness is measured against the TSM alternative, the rating system avoids crediting a less efficient property with benefits that could be achieved through low-cost actions that have already been taken by other properties competing for Federal assistance.

Since the rating system is used to make decisions within UMTA's capital program, the costs considered are total capital costs over the expected life of the project (typically 40 to 50 years). Benefits are also valued over the entire life of the project. From the Federal perspective, the benefits considered are:

- attraction of new transit riders;
- improvement in service (travel times) for existing riders; and
- reductions in operating and maintenance costs for transit operators.
The first two measures capture very well the direct benefits from a transportation improvement. They focus on transportation benefits, which are primary from the Federal perspective. The third measure reflects the Federal interest in reducing operating costs and deficits as a means of strengthening the financial position of local transit operators. It should be noted that where alternatives lead to increases in travel times or operating costs, these disbenefits are counted as added costs.

Obvious questions arise on the extent to which these few measures can capture the wide variety of benefits resulting from a major transit investment. Two considerations are key to the answer to these questions. First is the recognition that most of the secondary benefits of a transit project are direct consequences of the service and patronage impacts of that project. Because of this dependence, the measures are good surrogates for a wide range of non-transportation benefits. For example, where substantial numbers of new riders are gained, there will be associated benefits—less highway congestion, lower energy consumption and pollutant emissions, and so forth—whose magnitude depend directly on the magnitude of the ridership gain. Further, improvement in service to existing riders is a good indicator of improved mobility for the transit dependent and increased accessibility to employment locations.

Even such an indirect impact as economic development is well represented by gains in new ridership and improved service for existing riders. The likelihood that a transit project will have significant impacts on development patterns is largely determined by its ability to provide significant increases in accessibility and patronage. As a result, a project with little or no service and ridership impacts will likely have similarly modest development impacts. Thus, the evaluation system does recognize differences between projects in terms of their potential impacts on development.

The second key is that the function of the rating system is to allocate funds within a set budget. This task requires only the ordering of projects according to their relative merits rather than calculation of their absolute merits. Since the transportation benefits of a project are proportional to its overall benefits, the ordering of projects based on transportation benefits alone is the same ordering that would result if the secondary benefits were measured as well. Consequently, the indirect measurement of secondary benefits is quite adequate for the purposes of the rating system. Direct measurement of the secondary benefits would become critical only if the system were designed to judge the absolute merits of each project—whether its total benefits exceed its costs.

It is important to note that "new" riders are computed as the difference in ridership between two alternatives, not between two different years. Thus, new riders are generated only by the transit service differences between the two alternatives, not by any growth in ridership caused by changes in population and employment over time. This definition avoids any bias that might occur in the comparison of a project in a rapidly growing city with one in a city with a moderate growth rate.

The use of both the "new rider" and "existing rider" measures further ensures region. The "new riders" measure works well in situations where transit is
currently less competitive as an alternative to the automobile -- where that the evaluation is not biased toward any particular type of project or highway congestion makes bus service slow and unreliable, for example. In these situations, the primary objective is usually the attraction of new transit riders from their automobiles. However, in many other cities, transit is already a competitive alternative to the automobile -- often because of very high parking costs in the downtown. In these situations, the primary objective of a major improvement is better service for existing transit riders. Thus, the use of both the addition of new transit riders and service improvements provided to existing riders captures accurately the primary transportation benefits in very different settings.

In general, then, the attraction of new riders and service improvements for existing riders are good measures of the transportation benefits that are of primary Federal interest; they are also good indicators of a wide range of other benefits associated with major transit projects. Together with reductions in operating and maintenance costs, these indicators provide a comprehensive and objective basis for comparing proposed investments.

Local Fiscal Effort. Local funds are defined to include capital contributions from local and State governments, as well as transportation and other agencies. They do not include funds from UMTA's Section 9 program or the Interstate Transfer program. From UMTA's perspective, local fiscal effort plays three important roles in determining project merit. First, any excess match above the statutory minimum enables UMTA to assist a wider range of capital projects within its limited capital program. Second, local fiscal effort is an excellent indicator of the depth of the local commitment to transit in general and to the proposed improvement in particular. Third, a stable and reliable source of funding for the long-term operation of a local transit system reduces the risk that shortfalls in operating revenues will jeopardize the usefulness of the capital investment in new transit facilities.

An obvious concern here is the relative importance of the cost-effectiveness and local fiscal effort criteria. Local match and overmatch are treated by UMTA as credits against the cost of a project that make the Federal investment more productive. Thus, a significant local fiscal effort can work to make a proposal more attractive for Federal investment, but lack of local financing beyond the statutory minimum local match does not introduce any penalty. As a result, highly cost-effective projects remain attractive candidates for investment even if they do not include an overmatch. Cities with marginal projects can work to improve their attractiveness by increasing the local fiscal effort.

Private Sector Contributions. Again from the Federal perspective, capital contributions by the private sector act as both a means for reducing Federal costs and as an indicator of local support for the proposed investment. Therefore, private sector funds are treated similarly to funds from States and local governments.

The Results of Alternatives Analysis. One of the most important products of alternatives analysis is a determination on the potential cost-effectiveness of alternatives to the proposed investment. Where it is found that a more cost-effective alternative exists, a penalty is introduced to reflect the extent to which the proposal is a less productive use of Federal funds.
Participation of Disadvantaged Business Enterprises To be eligible for Federal funding, projects must comply with Section 105(f) of the Surface Transportation Assistance Act of 1982 that calls for 10 percent participation by Disadvantaged Business Enterprises. In developing final judgments on projects that are similar in terms of cost-effectiveness, UMTA will also consider the extent to which the projects may exceed this minimum threshold.

Support by Local Governments and the Community Since the most direct evidence of local support is the local financial commitment to the project, much of this consideration is captured in the criterion on local fiscal effort. Beyond the financial aspect, however, UMTA considers other local actions to improve the effectiveness of the proposed investment, including the adoption of supportive land use and transportation policies (zoning and parking management, for example). The level of community support, as evidenced by endorsements by local officials, civic groups, and private citizens, is also considered in UMTA's overall evaluation of a project, but is secondary to the strength of financial commitments and adoption of supporting actions.
3. Calculation of Indices of Project Merit and Application of Threshold Tests

To aid in the assignment of ratings to proposals for Federal funding assistance, UMTA computes two indices that represent the cost-effectiveness of the proposals from two perspectives. The data used in these computations are taken directly from the results of technical studies -- system planning, alternatives analysis, and preliminary engineering -- done by local governments and agencies with UMTA's technical and financial assistance. To be eligible for Federal funds, the proposals must then satisfy three threshold tests of their cost-effectiveness.

3(a) Calculation of the Indices

Two indices are used to provide two perspectives on a proposed transit investment. One perspective is that of the Federal government, in which the Federal funds needed for the project are compared to its total benefits. The other perspective is that of society in general, in which total funds needed -- regardless of their source -- are compared to total benefits.

The index representing the Federal perspective is computed as

\[
\text{Federal Index} = \frac{\Delta \text{SCAP} + \Delta \text{S0&M} + \Delta \text{STT} - \Delta \text{LOC}}{\Delta \text{RIDERS}}
\]

(1)

where the \(\Delta\)'s represent changes in costs and benefits compared to the TSM alternative, and

- \(\text{SCAP}\) = total capital costs, annualized over the life of the project;
- \(\text{S0&M}\) = annualized operating and maintenance costs;
- \(\text{STT}\) = annualized value of traveltime savings for existing riders;
- \(\text{LOC}\) = annualized value of local, State, and private capital funding;
- \(\text{RIDERS}\) = annual transit ridership, measured in "linked" trips.

The index used to represent society's perspective is similar, omitting only the term for local match, and is computed as

\[
\text{Total Index} = \frac{\Delta \text{SCAP} + \Delta \text{S0&M} + \Delta \text{STT}}{\Delta \text{RIDERS}}
\]

(2)

In both indices, "existing" riders are transit patrons carried by the TSM alternative in the forecast year -- that is, those riders who would exist without a new transit guideway. Values of time necessary to convert travel time into its monetary equivalent have been derived from a survey of research in the field. The research indicates that 1) the value of travel time is dependent on both the traveler's wage rate and trip purpose, and 2) that the values can be computed as approximately one-third the wage rate for work trips and one-sixth the wage rate for all other trips. Given the current national average wage rate, values of $4.00 and $2.00 per hour respectively have been used for 1984. These values will be updated periodically as wage rates change over time.
While both indices produce ratios with units of "added cost per new rider," they both reflect benefits to existing riders and savings in operating costs as well as the attraction of new riders. The indices can be interpreted as ratios between the necessary capital investment and the return in transit ridership, with credits for O&M cost savings, traveltime savings, and local funding used to offset some (or all) of the capital costs. Clearly, better projects will be indicated by lower values for both indices. For extremely attractive projects, total credits may exceed the capital cost and the resulting indices will be negative.

The indices can also be shown graphically. Figure 1 shows three alternatives within a given city, represented by their respective cost and ridership increments. The graph also effectively represents the TSM alternative since the TSM option is the basis for computing the increments and therefore lies at the origin. The figure could represent the computation of either index since they differ only in the use of local funding as one of the credits against capital costs. In Figure 1, it is clear that Alternative A is the most cost-effective, since it attracts the same number of riders at a lower cost than Alternative C and attracts more riders for the same cost as Alternative B. It is fairly easy to see that better alternatives are found higher and to the left of the graph where relatively more riders are gained at relatively lower costs. Thus, the slope of a line connecting an alternative with the origin is an indicator of the alternatives's cost-effectiveness and, in fact, the slope is the inverse of the index defined above.

![Figure 1](frontier.png)

Figure 2 illustrates the use of the graphical representation to identify the "best" alternatives from a given city. The figure connects the four alternatives (D, E, F, and G) that lie highest and furthest to the left. The resulting boundary, or "frontier," indicates the best that can be done with increasing levels of investment in the corridor. Alternatives H and I lie below and to the right of this frontier, indicating that they are inferior to the options found along the frontier. The shape of the frontier also demonstrates the declining productivity of the higher increments of investment.

![Figure 2](frontier.png)
in the hypothetical corridor. Each successive increment (from D to E, from E to F, etc.) results in a line segment with a flatter slope that reflects the lower returns per dollar of the additional investment.

The indices in equations (1) and (2) above depend only upon the differences in costs, travel impacts, and financing between the proposed investment and the TSM alternative. In addition, UMTA considers the results of alternatives analysis—that is, whether other major investment alternatives available locally are more cost-effective than the locally preferred option.

![Figure 3](image1.png)

**Figure 3**

![Figure 4](image2.png)

**Figure 4**

This situation is best illustrated graphically. In Figure 3, a locally preferred alternative (P) from City X is plotted with respect to its added costs and added ridership compared to the TSM alternative. For this example, the credits include local match and the index represented is for the Federal perspective. The added cost per added rider for this alternative is $40MM/25MM = $1.60. No other alternatives in City X produce added riders quite so efficiently since Alternative A yields new riders at a rate of $30MM/10MM = $3.00 each. This result is also represented graphically since Alternative A lies below and to the right of the cost-effectiveness frontier drawn between the origin and Alternative P.

The situation in Figure 4 for City Y is similar in that the locally preferred alternative (P*) has added costs and riders identical to those of Alternative P in City X, but different because Alternative A* yields new riders at a rate of $10MM/20MM = $0.50 each and is found on the frontier.

Figure 5 demonstrates the approach to including in the index recognition that in City Y a significantly more cost-effective option is available. The approach treats the investment in the preferred alternative as two segments: the first equal to that needed for Alternative A*, and the second equal to that needed beyond Alternative A* to reach Alternative P*. The composite index assigned to Alternative P* is a weighted average of the indices for each
of these two segments, where the weights are simply the increment of investment in each segment. In this case, the weight for the first segment is $10 million while that for the second is $30 million. The first segment is assigned the $0.50/rider value computed above for Alternative A*. The second segment is assigned a value reflecting the additional $30 million and 5 million riders associated with Alternative P* compared to A*: ($30MM/5MM) = $6.00/rider.

Thus, the (composite) Federal index for Alternative P* is

\[
\text{Federal Index} = \frac{($10MM \times $0.50) + ($30MM \times $6.00)}{$10MM + $30MM} = 4.63.
\]

Therefore, Alternative P* would be assigned a Federal composite index of $4.63 that reflects the existence of a more cost-effective major investment option in Alternative A*. A composite index for total costs would be computed analogously.

In cases where several lower cost alternatives are found on the frontier, the computation involves weighting over several segments. Where no lower cost alternatives lie on the frontier, the computation simplifies to a single segment.
3(b) Application of Threshold Tests

To ensure that projects being considered for Federal funding meet minimum levels of cost-effectiveness, UMTA applies several threshold or screening tests at three points in the project development process. The tests are applied for 1) entry into alternatives analysis, 2) entry into preliminary engineering, and 3) determination of funding eligibility at the conclusion of preliminary engineering. These threshold requirements apply to all proposals for funding assistance under Section 3, Section 9, or the Interstate Transfer program.

The purpose of these thresholds is to identify as early as possible those projects which clearly do not warrant Federal support. These threshold tests help avoid a prolonged and costly planning effort by local governments and UMTA in cases where Federal financial support is very unlikely. At the same time, the thresholds are sufficiently generous to ensure that potentially meritorious projects receive full consideration for funding.

To enter alternatives analysis, a corridor must satisfy two threshold tests:

1) The corridor must today have at least 15,000 daily transit (linked trips). This requirement ensures that at least a modest transit market exists in the corridor.

2) The major investment alternatives proposed for study must be potentially cost-effective, in the sense that they are likely to yield cost-effectiveness indices that are not excessive. The most direct way to demonstrate this condition is with preliminary cost and ridership estimates developed during system planning studies to update the region's long range transportation plan. The threshold value used in this test is based on a generous estimate of the operating cost, parking cost, and travel time savings for a typical auto commuter who shifts to a guideway transit mode of travel. This estimate is multiplied by a factor of three to recognize the presence of indirect benefits as well as the preliminary nature of cost and ridership estimates. For 1984, the threshold value is $10.00 per new transit trip.

Where Section 9 or formula-allocated Interstate Transfer funds are to be used for alternatives analysis, UMTA will concur in the analysis even if these threshold tests are not satisfied. In these cases, UMTA will issue a letter of exception to warn local officials that a fixed guideway project in the corridor would probably not qualify for UMTA capital assistance.

Regardless of the source of funds, projects must satisfy three thresholds to pass from alternatives analysis into preliminary engineering, and to qualify for consideration in the rating system at the end of preliminary engineering:

1) The alternative must produce a gain in transit ridership, compared to the TSM alternative. This threshold ensures that potential Federal investments demonstrate a basic level of performance.

2) The alternative must lie on the cost-effectiveness frontier. The impact of this threshold is illustrated in Figure 6. In this example, the locally preferred alternative P is not on the frontier defined by
the origin, A, and B. A full Federal share invested in Alternative P would represent an unproductive use of some of these funds since higher benefits could be achieved with a lower investment in Alternative A. This result is prevented by the requirement that, in terms of the Federal index, the alternative must lie on the frontier.

Local officials have the option of moving their preferred alternative to the frontier by increasing still further their commitment of local or private funds to the project. The necessary increase in local funds would reduce the Federal share of Alternative P sufficiently to move the alternative to point P' on the frontier in Figure 6. (The total index remains unchanged since it is independent of the sources of funds.) This device is labeled a "buy-back" where local officials are able to increase the attractiveness of the project for Federal funding by reducing Federal costs. Thus, this threshold limits potential Federal investment in a corridor to projects that offer the best return for increasing levels of investment. It also has the effect of making more Federal funds available for better projects: in Figure 6, more Federal funds would be available for Alternative A than Alternative P even though Alternative A is less costly.

3) **The alternative must not have an excessive composite index.** This requirement prevents entry of projects that satisfy the first two screens but represent very unproductive uses of Federal funds. The threshold value used in this test is again based on a generous estimate of the operating cost, parking cost, and travel time savings for a typical auto commuter who shifts to a guideway transit mode of

![Diagram](image-url)
travel. This estimate is multiplied by a factor of two to recognize the presence of indirect benefits as well as the more refined nature of the cost and ridership estimates produced during alternatives analysis. For 1984, the threshold value is $6.00 per new transit trip.

Figures 7 and 8 illustrate two ways in which locally preferred alternatives can survive the first two screens yet be very unattractive investments. In Figure 7, the locally preferred alternative is on the frontier but yields new riders at an extremely costly rate. In Figure 8, the local preference is again on the frontier but performs so poorly versus Alternative A that its composite index is extremely high.

![Diagram](image-url)

Index = $16.00/rider

Index = $0.25/rider

Composite Index = $12.30/rider
4. Assignment of Project Ratings

This section describes the timing and method UMTA uses to assign ratings to each project, based on the indices described above and on the overall performance of the project with respect to the Federal objectives in urban mass transportation.

4(a) Timing

Ratings are assigned by UMTA in the first quarter of each fiscal year to all projects that have completed preliminary engineering, have satisfied the threshold tests on cost-effectiveness, and are seeking (but have not yet obtained) a commitment from UMTA for discretionary funding. Preliminary ratings will also be included for projects that have emerged from alternatives analysis, and have satisfied an initial application of the threshold tests, but have not completed preliminary engineering. These projects, which are not yet ready for funding decisions, are included to indicate the relative merits of all projects that might be expected to compete for Federal funding within the current authorization cycle. The ratings will be shared with the Congress, as input to the annual appropriations process, and with local officials. For each project, the ratings will be accompanied by UMTA's analysis of the project's merit for Federal assistance.

As part of alternatives analysis, indices for all alternatives are computed as a reference for local officials choosing a preferred alternative. Once this alternative is identified, UMTA assigns a preliminary rating to the project and shares this rating with local officials. This rating also guides UMTA's decision on whether to concur in advancing a project into preliminary engineering. Decisions on entry into preliminary engineering may occur at any time of the year.

4(b) Development of Ratings

The approach UMTA uses to rate potential investments is similar to that used by private financial institutions to evaluate or grade investment options and assess risk. Private institutions typically use a set of objective criteria to place investment options into broad groups with similar worthiness. They then apply judgemental criteria to determine a final ranking.

Similarly, UMTA uses a two-step process to assign ratings to projects. First, the cost-effectiveness indices described above are used to determine the overall investment worthiness of each candidate project. Where projects exhibit similar degrees of cost-effectiveness, they are assigned the same rating as an indication of their similar investment worthiness. Second, all projects receiving the same rating are ranked against each other on the basis of specified policy objectives.

Hence, the UMTA rating system relies upon informed judgment to establish the final rankings of projects that exhibit comparable levels of investment worthiness. Rather than trying to produce an automatic, discrete ranking of projects on the basis of a single measure, the rating system instead recognizes the margin of error implicit in forecasting ridership and estimating costs, and relies upon other factors to establish the final rankings of projects with similar cost-effectiveness indices.
Step 1: Initial Determination of Project Ratings

As a first step in assigning ratings to candidate projects, UMTA computes the two indices of project merit, Federal and total, for each eligible project. Data on capital costs, operating and maintenance costs, ridership, travel time, and local financing are those produced by local project sponsors and documented in the (Draft or Final) Environmental Impact Statement (EIS) and Preferred Alternative Report. Where additional planning and engineering work has been done since the EIS, or where the data in the EIS is incomplete or outdated, UMTA and the local project sponsor will reach agreement on the estimates of ridership, travel time and costs to be used. This will help to ensure that the project ratings reflect the latest information available on each project. In each case, UMTA will review the methods and assumptions used to develop the ridership, travel time, and cost estimates in order to ensure that these forecasts are technically sound and that they are comparable with the forecasts developed for other projects.

The two indices of project merit are used to classify projects according to their investment worthiness. In some cases, however, the indices do not clearly distinguish between the projects. For example, given the uncertainty inherent in forecasting project costs and benefits, two projects with Federal indices of $1.50 per new rider and $1.70 are considered indistinguishable in terms of the indices. In such cases, projects are assigned the same rating.

Projects that perform well on both the Federal and total cost-effectiveness indices are deemed to represent the best use of available Federal resources and are assigned a high rating. Projects that perform poorly on both are considered least worthy among the eligible projects and receive a low rating. The remaining projects are assigned a rating that reflects their moderate attractiveness as potential investments. Depending on the number and differences among these remaining projects, there may be more than one class of projects in this intermediate range.

Local officials can influence the rating given to their project through their decisions on mode, alignment, design, and financing. The most effective way for local officials to compete for Federal funding is to select a highly cost-effective alternative at the conclusion of alternatives analysis. Once an alternative is chosen, local officials can improve the project's rating by taking steps to improve its indices. For example, local officials might change the scope or design of the project to reduce its capital costs, enhance its ridership potential, or further improve service to existing riders.

In assigning project ratings, UMTA examines both the Federal and total cost-effectiveness indices. Since only those projects that perform well on both indices are assigned the highest rating, a project that performs poorly in terms of total cost-effectiveness cannot be upgraded to a highly rated one solely because of a high local overmatch that produces a competitive Federal index. At best, such a project might receive a middle rating on the basis of its improved trade-off between the necessary Federal investment and the project's transportation benefits.
Step 2: Establishment of Final Ordering of Projects

Within each set of projects that receive the same rating, UMTA orders the projects in terms of their overall consistency with the objectives and criteria discussed above. This is done judgmentally and results only in the ordering of all projects with the same rating, not in the assignment of a new rating to any project. Local financial commitment, particularly the stability and reliability of local sources of operating funds, is a primary criterion in the ordering. To evaluate the stability and reliability of these funding sources, UMTA and its financial advisors will determine whether local operating funds are derived from dedicated sources, the extent to which these sources will cover projected operating assistance requirements, and the longevity of the dedicated funding source. Preference will be given to projects that exhibit the most stable and reliable funding sources. This will help reduce the risk that a shortfall in local operating revenues will ultimately lead to a reduction in service from the levels presumed in the Federal decision to support the project.

Other factors that may influence a project's final ranking include an unusually high level of community support, particularly when demonstrated by commitments to supporting land use and transportation policies. In addition, UMTA would also consider an outstanding effort to obtain the participation of disadvantaged businesses in project planning, design, construction, and operation. Finally, preference will be given whenever local officials agree to limit their future use of Section 9 revenues for operating assistance.
5. Use of Project Ratings in UMTA Funding Decisions

The rating system has been designed to help the Federal government direct those discretionary resources that are available for major investment projects toward those projects that offer the greatest return on the Federal investment. Fixed guideway projects that rate most highly under the system are given priority for discretionary funds authorized by the Congress under Section 3 of the Urban Mass Transportation Act and the Interstate Transfer program of Title 23. Similarly, projects that rate poorly under the rating system are given a low priority for funding, and are funded only after all other eligible projects. Fixed guideway proposals that fail to satisfy the threshold criteria noted above are considered ineligible for Federal funding, both discretionary and formula.

There are two ways in which the ratings affect Federal funding decisions. First, the project ratings developed by UMTA in the first quarter of each fiscal year are shared with the Office of the Secretary of Transportation, the Office of Management and Budget, the Congress, and the public. These evaluations help guide funding decisions during that fiscal year. All interested parties will then have the benefit of objective information on the relative merits of projects that are in a position to receive a capital grant. They will also be aware of the merits of other projects not yet finished preliminary engineering that are likely to seek Federal funds during the authorization period.

Second, project ratings are used by UMTA in deciding on whether to issue a Letter of Intent (LOI) to fund final design and construction. Upon the completion of the preliminary engineering phase, local officials may ask UMTA for a Letter of Intent to provide Section 3 discretionary funds for final design and construction. Letters of Intent are used to document UMTA's intention to obligate Section 3 funds for a particular project, but are not a Federal obligation or administrative commitment. The total amount of potential Federal obligations covered by all outstanding Letters of Intent cannot exceed the amount authorized to carry out Section 3, less an amount necessary for other grants not covered by Letters of Intent (i.e., the bus and rail modernization programs).

In order to optimize the use of available resources over the authorization period, UMTA will use the rating system to determine which projects should receive Letters of Intent. Such letters will be offered to cost-effective projects, in order of their performance in the rating system, up to the point where the remaining authorization for new start projects is exhausted. In selecting projects for Letters of Intent, UMTA will consider all projects expected to become eligible for funding during the current authorization cycle, not just those eligible in the current year. When the competing proposals include a highly rated project that would consume all available resources, UMTA will seek to negotiate some reasonable compromise that would allow other worthy projects to share in the benefits of the program.